NATIONAL ELECTRIC LIGHT ASSOCIATION

Twenty-eighth Convention
Denver-Colorado Springs, Colo.
June 6–11, 1905

Ernest H. Davis

Electric Light

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PUBLISHED ...

NATIONAL Electric Light ASSOCIATION

TWENTY-EIGHTH CONVENTION

VOLUME I

Papers, Reports and Discussions

DENVER-COLORADO SPRINGS, COLO.
June 6, 7, 8, 9, 10, 11, 1905

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AUTHORS' INDEX

WITH SYNOPSES OF PAPERS

BOGEN, LOUIS E. *Notes on Rotary Converters and Motor-Generators:* Tendency is to install alternators, owing to the wider range of distribution and consequent higher voltage employed. Conversion of energy is done either by means of the rotary converter or motor-generator. The author discusses the advantages and salient points of these two methods—the speed, capacity, frequency, method of starting and synchronizing and field excitation of rotaries. Under motor-generators he takes up the different types in use, their relative advantages, and methods of starting and operation. Paper contains illustration of machines and diagrams of connections.
Discussion by Renshaw, Dow, Gille. 90 to 107.

BRITTON, JOHN A. *Long-Distance High-Tension Transmission in California:* History of the development of long-distance transmission in California and the present high state reached. The geographical location of the systems. Author deals with the difficulties that had to be overcome due to the local conditions encountered. These are well illustrated by photographs. The transmission lines are mainly dealt with. The cables, poles, insulators and switches employed are shown and described. Source of power and the care given to all apparatus are also described. Paper contains illustrations and diagrams. 213 to 233.

CATO, GEO. W. *Report of the Committee for the Investigation of the Steam Turbine.* For synopsis see Eglin, W. C. L.

CLARK, WALLACE S. *The Choice of an Insulated Cable:* It is important to make a proper selection of cable for both constant and variable-current work. Strength of cables, economy of use in ducts, and the variation of cost of cable for different sizes and voltages. The use of single and multiconductor cables is discussed at great length and the adaptation of the various insulating materials for different service. The successful employment of varnished cambric. Its advantages for cable insulation. Paper concludes by mentioning the proper requirements as to test pressures. Illustrated by curves and sketches. 291 to 302.

COLE, G. PERCY. *A New Type of Single-Phase, Alternating-Current Motor for Elevator Work:* Author mentions the advantages of the electric over the hydraulic elevator in point of cost, operation, and simplicity. The types of electric motors generally employed. The impossibility of obtaining direct current in many localities, and the present growth of alternating-current installations. The objections to the induction motor. The requirements of an ideal alternating-current motor. The Schuler motor, employing the principle of the repulsion motor, is advocated for this service and its advantages dwelt upon. Paper contains illustrations and diagrams.
Discussion by Renshaw, Eglin, Dow, Cole. 203 to 211.

CROUSE, J. ROBERT. *Co-operative Plan of Lamp Manufacturers for Business Promotion, with a Suggested Broader Plan:* A paper outlining the plans of the Association of Licensed Manufacturers of Incandescent Lamps for an advertising campaign, for which the sum of $10,000 was contributed, to co-operate with the central stations to introduce the use of incandescent lamps more largely. The author recommends the appropriation of one-fifth of one per cent of the gross receipts of all manufacturers of electrical apparatus; this to form a fund for a vigorous and carefully-conducted campaign of advertising. 368 to 371.

are mentioned and descriptions of main features, as far as possible, given. The committee goes into detail on the subject of condensing apparatus, mentioning the various difficulties encountered, and suggests remedies for same. The importance of high vacuum in turbine work is discussed. Results are given of a test on 1000-kw Parsons turbine of the Hartford Electric Light Company by the committee's engineers. Report contains tables, curves, diagrams, illustrations of turbine parts, and tabulated data of importance.
Discussion by McCabe, Kruesi, Eglin. 136 to 172, 211, 212.

HALL, DAVID. *The Paramount Importance of Selection of Standard in Preference to Special Machinery:* The author claims the following advantages to both purchaser and manufacturer: a standard machine is a tried machine, its weak points have been corrected, tests have established its efficiency and capacity, its various parts have been perfected, it has been more improved and simplified than a new special machine. In case of necessity spare parts can be obtained with least delay or expense. A standard machine, owing to its greater simplicity and the number in operation elsewhere, is better understood by new help. The price of standard machinery is much better and deliveries are quicker. Some of the disadvantages of special machinery: they are untried, less improved, more complicated. New plans, patterns and parts cause deliveries to be long delayed. Spare parts hard to obtain. Prices are higher, and machine often does not satisfy any better than a standard. In case of expansion, necessitating disposal of old machinery, special machines can not be adapted to conditions where standard could be used. Author recommends, therefore, that bids be so worded as to allow the manufacturer a certain amount of leeway. State conditions and work to be done and let manufacturer prescribe the machine.
Discussion by McCabe, Hartman. 50 to 54.

HANCOCK, W. P. *The Organization of Working Forces in Large Power-Houses:* The generating department organization of the Boston Edison Company taken as an illustration. The paper has three main headings: The Steam Division; The Electrical Division; The Storage-Battery Division. These are again subdivided into the following titles: The Steam Division: Chief Engineer; First Assistant Engineer; Watch Engineers; The Oilers; The Boiler-Room; The Water Tenders; The Firemen. The Electrical Division has the following subdivisions: The Chief Operator; Assistant Operator; Watch Operator. The Storage-Battery Division is subdivided into Head of Department and Assistant Head of Department. Under each subdivision are described the duties and responsibilities of the various employees; the treatment of help; their selection and the question of wages.
Discussion by Jackson, Kruesi, Hartman, Honnold, Scovil, Dunham. 116 to 135.

INGALLS, PERCY. *Advertising Methods:* The report deals with the various methods of advertising employed by central stations, as sent in answer to the author's circular of inquiry. These are treated in detail under the following headings: Newspapers; Monthly Bulletins; Novelties; Calendars; Street-Car Advertising; Electric Signs; Display-Rooms; An Advertising Campaign. The paper is profusely illustrated by reproductions of letters, pamphlets, bulletins and various devices used in an advertising campaign. 319 to 343.
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Vapor Arc; Other Illuminants; Electric Heating; Tantalum Incandescent Lamp; The Osmium Lamp; The Cadmium Lamp; Electric Power for Refrigeration.
Discussion by Williams, Eglin, Dow, Scovil. 13 to 41, 107 to 115.

MAUNSELL, C. R. *Report of the Committee on District Heating.* For synopsis see Blood, W. H., Jr.

MOULTROP, I. E. *Report of the Committee for the Investigation of the Steam Turbine.* For synopsis see Eglin, W. C. L.

NIESZ, HOMER E. *Question Box.* Volume II.

RENSHAW, CLARENCE. *Series Alternating-Current Motors for Industrial Work:* Description of a series single-phase commutator-type motor for operation of cranes, hoists and similar machinery. This motor has in general the same characteristics as the direct-current series motor, *i. e.,* large starting torque; torque increasing much more than the current; speed varying inversely as the load. Method of speed control, and type of brakes employed, are also described. Paper is illustrated by cuts of various apparatus and performance curves. 191 to 202.

ROBERTS, E. R. *The Nernst Lamp—Its Present Performance and Commercial Status:* The paper gives the results of a series of photometric and life tests on standard Nernst lamps, made by the Nernst Lamp Company. Tests made were on the one, two, three, four and six-glower lamps. Different kinds of glassware were used. Paper is illustrated by tables, curves, diagrams and reproductions of photographs. The advantages claimed for the Nernst lamp are quality of color, steadiness, economy and neat appearance. The multiglower type compares very favorably with the arc lamp, and the smaller size makes it possible for central stations to compete with the multiple-burner gas unit.
Discussion by Hazard, Roberts, Williams, Russell, Dunham. 256 to 277.

SKINNER, C. E. *Insulation Testing—Apparatus and Methods:* The author discusses the elements that should be considered in the design, selection and use of apparatus for making dielectric tests. The following should be taken into consideration: maximum testing voltage, frequency, static capacity of apparatus, variation and measurement of testing voltage, provision for locating faults, portability of apparatus, rating of testing transformers. Testing methods are described and diagrams given. 55 to 77.

SPEER, HON. ROBERT W., Mayor of Denver. *Address of Welcome to the Twenty-eighth Convention:* In welcoming the members to Denver the mayor mentions the great resources and the fruitfulness of the soil, the healthfulness and variety of the climate, and the prospect in store for future developers. 2, 3.

STEWART, ROBERT S., AND ALEX DOW. *Report on Present Methods of Protection from Lightning and Other Static Disturbances.* For summary see Dow, Alex.

VREDENBURGH, LARUE. *Sign and Decorative Lighting:* Author proposes to treat the subject from the commercial point of view. The wide-awake merchant always looks for new methods of obtaining new trade.

The large increase of electric signs shows the popularity of this method of advertising. It pays the central station to carry on a persistent and systematic advertising campaign. Place the sign business in the hands of an expert who can advise a prospective customer on size and style of sign most efficient and economical for his purpose. Many municipalities place a restriction on the size and position of sign. Decorative lighting by means of the Elblight system and the miniature decorative lamp sets. Illuminated bill-boards; the talking sign. 344 to 350.

WAGONER, P. D. *Mercury-Arc Rectifier:* Author discusses the various methods of converting alternating current to direct current e.m.f. The motor-generator, single-phase rotary converter and mechanical and chemical converters are discussed. The theory of the mercury-arc rectifier is expounded and the use of reactance in conjunction therewith explained. The means of starting, operating and maintaining the rectifier are taken up, as also the efficiency, capacity and power factor. Use of the rectifier for charging storage batteries is fully treated and other possible uses are intimated. Paper is illustrated by curves, diagrams and photographs.

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WALLACE, R. S. *Report of the Committee on District Heating.* For synopsis see Blood, W. H., Jr.

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CONVENTIONS OF THE ASSOCIATION

First	Chicago, February 25, 26, 1885
Second	New York, August 18, 19, 20, 1885
Third	Baltimore, February 10, 11, 12, 1886
Fourth	Detroit, August 31, September 1, 2, 1886
Fifth	Philadelphia, February 15, 16, 17, 1887
Sixth	Boston, August 9, 10, 11, 1887
Seventh	Pittsburgh, February 21, 22, 23, 1888
Eighth	New York, August 29, 30, 31, 1888
Ninth	Chicago, February 19, 20, 21, 1889
Tenth	Niagara Falls, August 6, 7, 8, 1889
Eleventh	Kansas City, February 11, 12, 13, 14, 1890
Twelfth	Cape May, August 19, 20, 21, 1890
Thirteenth	Providence, February 17, 18, 19, 1891
Fourteenth	Montreal, September 7, 8, 9, 10, 1891
Fifteenth	Buffalo, February 23, 24, 25, 1892
Sixteenth	St. Louis, February 28, March 1, 2, 1893
Seventeenth	Washington, February 27, 28, March 1, 2, 1894
Eighteenth	Cleveland, February 19, 20, 21, 1895
Nineteenth	New York, May 5, 6, 7, 1896
Twentieth	Niagara Falls, June 8, 9, 10, 1897
Twenty-first	Chicago, June 7, 8, 9, 1898
Twenty-second	New York, May 23, 24, 25, 1899
Twenty-third	Chicago, May 22, 23, 24, 1900
Twenty-fourth	Niagara Falls, May 21, 22, 23, 1901
Twenty-fifth	Cincinnati, May 20, 21, 22, 1902
Twenty-sixth	Chicago, May 26, 27, 28, 1903
Twenty-seventh	Boston, May 24, 25, 26, 1904
Twenty-eighth	Denver-Colorado Springs, June 6, 7, 8, 9, 10, 11, 1905

PRESIDENTS OF THE ASSOCIATION

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James I. Ayer, Boston, Massachusetts
Cyrus O. Baker, Jr., New York City
Frederic Nicholls, Toronto, Canada

* Deceased

MEMBER COMPANIES—CLASS A

ALABAMA

ANNISTON,	Anniston Electric and Gas Company
BIRMINGHAM,	Birmingham Railway, Light and Power Company
DEMOPOLIS,	Demopolis Electric Light and Power Company
MOBILE,	Mobile Light and Railroad Company
MONTGOMERY,	Montgomery Light and Water Power Company

ARIZONA

PHŒNIX,	Phœnix Light and Fuel Company
PRESCOTT,	The Prescott Electric Company
TUCSON,	The Tucson Gas, Electric Light and Power Company

ARKANSAS

EUREKA SPRINGS,	Citizens' Electric Company
FORT SMITH,	Fort Smith Light and Traction Company
HOT SPRINGS,	Hot Springs Water Company
LITTLE ROCK,	Little Rock Railway and Electric Company
PINE BLUFF,	Pine Bluff Light and Water Company
TEXARKANA,	Texarkana Gas and Electric Company

CALIFORNIA

EUREKA,	Eureka Lighting Company
FORTUNA,	Fortuna Lighting Company
LOS ANGELES,	Los Angeles Gas and Electric Company
	Pacific Light and Power Company
	The Edison Electric Company
MARYSVILLE,	Marysville Gas and Electric Company
MONTEREY,	Monterey County Gas and Electric Company
OAKLAND,	Oakland Gas, Light and Heat Company
ONTARIO,	Ontario Power Company
OXNARD,	Oxnard Light and Water Company
SACRAMENTO,	Sacramento Electric, Gas and Railway Company
SAN FRANCISCO,	San Francisco Gas and Electric Company
SAN LEANDRO,	Suburban Electric Light Company
STOCKTON,	Stockton Gas and Electric Company

COLORADO

ASPEN,	The Roaring Fork Electric Light and Power Company
BOULDER,	The Boulder Electric Light and Power Company

COLORADO—*Continued*

CAÑON CITY,	The Colorado Light and Power Company
COLORADO SPRINGS,	The Colorado Springs Electric Company
DENVER,	Denver Gas and Electric Company
	The Mountain Electric Company
DURANGO,	Durango Light and Power Company
FORT COLLINS,	The Larimer Light and Power Company
GEORGETOWN,	The United Light and Power Company
GOLDEN,	The Golden Illuminating Company
GRAND JUNCTION,	Grand Junction Electric and Gas Company
IDAHO SPRINGS,	Cascade Electric Company
	Consolidated Gem Mines Company, Electrical Department
LAMAR,	The Lamar Electric Company
LAS ANIMAS,	The Las Animas Electric Company
LEADVILLE,	Leadville Gas and Electric Company
LITTLETON,	The Arapahoe Electric Light and Power Company
LOUISVILLE,	Consumers' Electric Company
MANITOU,	Manitou Electric Company
OURAY,	The Ouray Electric Light and Power Company
PUEBLO,	The Pueblo and Suburban Traction and Lighting Company
TELLURIDE,	The Telluride Electric Light and Power Company
	The Telluride Power Company

CONNECTICUT

BRANFORD,	Branford Lighting and Water Company
BRIDGEPORT,	Connecticut Railway and Lighting Company
DANBURY,	Danbury and Bethel Gas and Electric Light Company
DANIELSON,	People's Light and Power Company
DERBY,	Derby Gas Company
HARTFORD,	The Hartford Electric Light Company
LITCHFIELD,	The Litchfield Electric Light and Power Company
MERIDEN,	Meriden Electric Light Company
NEW LONDON,	New London Gas and Electric Company
ROCKVILLE,	The Rockville Gas and Electric Company
SOUTH MANCHESTER,	South Manchester Light, Power and Tramway Company
STAMFORD,	Stamford Gas and Electric Company
SUFFIELD,	Village Water Company
THOMPSONVILLE,	Enfield Electric Light and Power Company
UNIONVILLE,	The Union Electric Light and Power Company
WESTPORT,	The Westport Water and Electric Light Company

DELAWARE

WILMINGTON,	The Wilmington City Electric Company

DISTRICT OF COLUMBIA

WASHINGTON,	Potomac Electric Power Company

FLORIDA

KEY WEST,	The Key West Electric Company
TAMPA,	Tampa Electric Company

GEORGIA

AMERICUS,	Americus Illuminating and Power Company
ATHENS,	Athens Electric Railway Company
ATLANTA,	Georgia Railway and Electric Company
AUGUSTA,	Augusta Railway and Electric Company
COLUMBUS,	The Columbus Railroad Company
SAVANNAH,	Savannah Electric Company

HAWAII

HILO,	Hilo Electric Light Company, Limited
HONOLULU,	Hawaiian Electric Company, Limited

IDAHO

BOISÉ,	The Capital Electric Light, Motor and Gas Company
LEWISTON,	Lewiston-Clarkston Company
MOSCOW,	Moscow Electric Light and Power Company
POCATELLO,	American Falls Power, Light and Water Company

ILLINOIS

ABINGDON,	Abingdon Electric Company
ALTON,	Alton Gas and Electric Company
BEARDSTOWN,	Beardstown Electric Light and Power Company
BLOOMINGTON,	Bloomington and Normal Railway, Electric and Heating Company
CANTON,	People's Gas and Electric Light Company
CENTRALIA,	Centralia Gas and Electric Company
CHICAGO,	Chicago Edison Company
	Chicago Sectional Electric Underground Company
	Commonwealth Electric Company
CLINTON,	Clinton Gas Company
DEKALB,	DeKalb-Sycamore Electric Company
EDWARDSVILLE,	Edwardsville Electric Light and Power Company
EVANSTON,	North Shore Electric Company
FREEPORT,	Freeport Railway, Light and Power Company
HILLSBORO,	Hillsboro Electric Light and Power Company
JACKSONVILLE,	Jacksonville Gas Light and Coke Company
JOLIET,	Economy Light and Power Company

ILLINOIS—*Continued*

MOLINE,	People's Power Company
MT. CARMEL,	The New Electric Company
NOKOMIS,	Nokomis Electric Light and Power Company
OAK PARK,	Oak Park Yaryan Company
PEORIA,	Peoria Gas and Electric Company
PONTIAC,	Pontiac Light and Water Company
QUINCY,	Quincy Gas, Electric and Heating Company
	The Independent Light and Power Company
ROCKFORD,	Rockford Edison Company
SPRINGFIELD,	Springfield Electric Light and Power Company
STREATOR,	Streator Gas and Light Company
TAYLORVILLE,	Taylorville Electric Company
WARSAW,	Warsaw Electric Plant
WATSEKA,	Watseka Electric and Heat Company

INDIANA

ELKHART,	Elkhart Electric Company
ELWOOD,	Elwood Electric Light Company
EVANSVILLE,	Evansville Gas and Electric Light Company
FORT WAYNE,	Fort Wayne and Wabash Valley Traction Company
GOSHEN,	The Hawks Electric Company
KOKOMO,	Kokomo, Marion and Western Traction Company
MADISON,	Madison Lighting Company
MARION,	Marion Light and Heating Company
NEW ALBANY,	United Gas and Electric Company
RICHMOND,	Richmond Light and Interurban Railway Company
SOUTH BEND,	South Bend Electric Company
TERRE HAUTE,	Terre Haute Traction and Light Company
WABASH,	Wabash Water and Light Company

IOWA

CEDAR RAPIDS,	Cedar Rapids and Iowa City Railway and Light Company
CORNING,	Corning Light, Heat and Power Company
DAVENPORT,	People's Light Company
DECORAH,	The Decorah Electric Light Company
DES MOINES,	Des Moines Edison Light Company
DUBUQUE,	Union Electric Company
IOWA CITY,	Iowa City Electric Light Company
KEOKUK,	Keokuk Electric Railway and Power Company
MASON CITY,	Brice Gas and Electric Company
OTTUMWA,	Ottumwa Traction and Light Company
RED OAK,	Red Oak Electric Company
SIOUX CITY,	Sioux City Gas and Electric Company
	Sioux City Service Company
WATERLOO,	Waterloo and Cedar Falls Gas and Electric Light Company

KANSAS

ABILENE,	Abilene Electric Light Works
BELOIT,	Beloit Light and Water Company
CLAY CENTER,	F. L. Williamson and Company
COLUMBUS,	The Columbus Electric Company
HOLTON,	Holton Electric Company
HUTCHINSON,	The Water, Light and Gas Company
JUNCTION CITY,	The Electric Railway, Light and Ice Company
LEAVENWORTH,	Leavenworth Light and Heating Company
TOPEKA,	The Topeka Edison Company

KENTUCKY

COVINGTON,	Union Light, Heat and Power Company
LEXINGTON,	Lexington Railway Company
LOUISVILLE,	Louisville Lighting Company
PADUCAH,	The Paducah City Railway Company

LOUISIANA

LAKE CHARLES,	The Lake Charles Ice, Light and Water Works Company
NEW ORLEANS,	New Orleans and Carrollton Railroad, Light and Power Company
SHREVEPORT,	Shreveport Gas, Electric Light and Power Company

MAINE

AUBURN,	The Lewiston and Auburn Electric Light Company
BANGOR,	Bangor Railway and Electric Company
BRUNSWICK,	The Brunswick Electric Light and Power Company
KEZAR FALLS,	Cornish and Kezar Falls Light and Power Company
OAKLAND,	Oakland Electric Company
PORTLAND,	Consolidated Electric Light Company of Maine
	Portland Lighting and Power Company
SKOWHEGAN,	Skowhegan Electric Light Company
WATERVILLE,	Waterville and Fairfield Railway and Light Company

MARYLAND

BALTIMORE,	Consolidated Gas Electric Light and Power Company
CRISFIELD,	Crisfield Ice Manufacturing Company
FREDERICK,	Frederick Gas and Electric Company
HAVRE DE GRACE,	The Havre de Grace Electric Company

MASSACHUSETTS

AMHERST,	Amherst Gas Company
ATTLEBORO,	Attleboro Steam and Electric Company
BEVERLY,	Beverly Gas and Electric Company
BOSTON,	The Edison Electric Illuminating Company of Boston
BROCKTON,	Edison Electric Illuminating Company of Brockton

MASSACHUSETTS—*Continued*

Brookline,	Boston Consolidated Gas Company
Cambridge,	Cambridge Electric Light Company
Chelsea,	Chelsea Gas Light Company
Clinton,	Clinton Gas Light Company
Cohasset,	The Cohasset Electric Company
Fall River,	Fall River Electric Light Company
Fitchburg,	Fitchburg Gas and Electric Light Company
Gardner,	Gardner Electric Light Company
Great Barrington,	Great Barrington Electric Light Company
Hyde Park,	Hyde Park Electric Light Company
Lawrence,	Lawrence Gas Company
Lee,	Lee Electric Company
Leicester,	Rawson Light and Power Company
Lexington,	Lexington Gas and Electric Company
Lowell,	The Lowell Electric Light Corporation
Lynn,	Lynn Gas and Electric Company
Malden,	Malden Electric Company
Marlborough,	Marlborough Electric Company
New Bedford,	New Bedford Gas and Edison Light Company
Newton,	Newton and Watertown Gas Light Company
North Adams,	North Adams Gas Light Company
Palmer,	Central Massachusetts Electric Company
Pittsfield,	Pittsfield Electric Company
Plymouth,	Plymouth Electric Light Company
Revere,	Suburban Gas and Electric Company
Salem,	Salem Electric Lighting Company
Southbridge,	Andrew F. Hall
Springfield,	United Electric Light Company
Webster,	Webster Electric Company
Westboro,	Westboro Gas and Electric Company
Winchendon,	Winchendon Electric Light and Power Company
Woburn,	Woburn Light, Heat and Power Company
Worcester,	Worcester Electric Light Company

MICHIGAN

Adrian,	Citizens' Light and Power Company
Alpena,	Alpena Electric Light Company
Ann Arbor,	Washtenaw Light and Power Company
Big Rapids,	W. E. Donley Electric Light and Power Company
Brooklyn,	L. W. Greene
Cheboygan,	Cheboygan Electric Light and Power Company
Corunna,	Shiawassee Light and Power Company
Detroit,	Peninsular Electric Light Company
Houghton,	Houghton County Electric Light Company
Ionia,	Ionia Water Power Electric Company
Ishpeming,	Marquette County Gas Light and Traction Company
Jackson,	Commonwealth Power Company

MICHIGAN—*Continued*

MANCELONA,	Mancelona Electric Light and Power Company
MANISTIQUE,	Manistique Light and Power Company
PLAINWELL,	Brownell Electric Company
PORT HURON,	Port Huron Light and Power Company
SAGINAW,	Bartlett Illuminating Company
ST. JOSEPH,	Benton Harbor and St. Joseph Electric Railway and Light Company
SAULT STE. MARIE,	Edison Sault Electric Company

MINNESOTA

ALBERT LEA,	Albert Lea Light and Power Company
CROOKSTON,	Crookston Water Works, Power and Light Company
DULUTH,	Duluth General Electric Company
FARIBAULT,	The Faribault Gas and Electric Company
LITTLE FALLS,	The Little Falls Water Power Company of Minnesota
MINNEAPOLIS,	The Minneapolis General Electric Company
MONTEVIDEO,	Montevideo Electric Light and Power Company
PIPESTONE,	Pipestone Electric Light, Heat and Power Company
RED WING,	Red Wing Gas and Electric Company
ST. CLOUD,	Public Service Company of St. Cloud
ST. PAUL,	Edison Electric Light and Power Company
WINONA,	Winona Railway and Light Company

MISSISSIPPI

COLUMBUS,	Columbus Light and Power Company
HATTIESBURG,	Hattiesburg Light and Power Company
MERIDIAN,	Meridian Light and Railway Company
VICKSBURG,	Vicksburg Railway and Light Company

MISSOURI

DE SOTO,	Consumers' Electric Light and Power Company
EXCELSIOR SPRINGS,	The Excelsior Springs Light, Power, Heat and Water Company
KANSAS CITY,	Kansas City Electric Light Company
ST. JOSEPH,	St. Joseph Railway, Light, Heat and Power Company
ST. LOUIS,	The Laclede Gas Light Company
	The Laclede Power Company of St. Louis
	Union Electric Light and Power Company
SPRINGFIELD,	Springfield Gas and Electric Company
WASHINGTON,	Tibbe Electric Company

MONTANA

ANACONDA,	The Anaconda Copper Mining Company, Electric Light and Railway Department
BIG TIMBER,	Big Timber Electric Light and Power Company

MONTANA—*Continued*

BILLINGS,	Billings Water Power Company
BUTTE,	Butte Electric and Power Company
GREAT FALLS,	Boston and Great Falls Electric Light and Power Company
HELENA,	Helena Light and Traction Company
KALISPELL,	Big Fork Electric Power and Light Company
MISSOULA,	Missoula Light and Water Company

NEBRASKA

BEATRICE,	Beatrice Electric Company
BLAIR,	Blair Electric Light and Power Company
GRAND ISLAND,	Grand Island Electric Company
KEARNEY,	The Northwestern Electric, Heat and Power Company
LINCOLN,	Lincoln Gas and Electric Company
OMAHA,	Omaha Electric Light and Power Company

NEW HAMPSHIRE

CONCORD,	Concord Electric Company
DOVER,	United Gas and Electric Company
FRANKLIN FALLS,	The Franklin Light and Power Company
KEENE,	Keene Gas and Electric Company
MANCHESTER,	Manchester Traction, Light and Power Company
NASHUA,	Nashua Light, Heat and Power Company
NEWPORT,	Newport Electric Light Company
PENACOOK,	Penacook Electric Light Company
PORTSMOUTH,	Rockingham County Light and Power Company

NEW JERSEY

ATLANTIC CITY,	The Atlantic Electric Light and Power Company
BRIDGETON,	Bridgeton Electric Company
DOVER,	Dover Electric Light Company
EGG HARBOR,	Atlantic County Electric Company
HACKENSACK,	The Gas and Electric Company of Bergen County
LAMBERTVILLE,	Lambertville Heat, Light and Power Company
LONG BRANCH,	Consolidated Gas Company of New Jersey
NEWARK,	Public Service Corporation of New Jersey, Electric Department
SUMMIT,	Commonwealth Water and Light Company

NEW MEXICO

ALBUQUERQUE,	The Albuquerque Gas, Electric Light and Power Company
LAS VEGAS,	Las Vegas Light and Fuel Company

NEW YORK

ALBION,	Albion Power Company
AMSTERDAM,	Edison Electric Light and Power Company
AUBURN,	Auburn Light, Heat and Power Company
BINGHAMTON,	Binghamton Light, Heat and Power Company
BROOKLYN,	Edison Electric Illuminating Company of Brooklyn
BUFFALO,	Buffalo General Electric Company
CAZENOVIA,	Union Electric Company
COOPERSTOWN,	The Clinton Mills Power Company
DUNDEE,	Dundee Electric Light, Heat and Power Plant
ELMIRA,	Elmira Water, Light and Railroad Company
FAR ROCKAWAY,	Queens Borough Gas and Electric Company
FISHKILL-ON-HUDSON	Southern Dutchess Gas and Electric Company
FULTON,	Fulton Light, Heat and Power Company
GLENS FALLS,	Hudson River Water Power Company
GLOVERSVILLE,	Fulton County Gas and Electric Company
GREENWICH,	Consolidated Electric Company
HOOSICK FALLS,	Hoosick Falls Illuminating Company
ITHACA,	Ithaca Electric Light and Power Company
JAMESTOWN,	Jamestown Lighting and Power Company
KEESEVILLE,	Keeseville Electric Company
KINGSTON,	Kingston Gas and Electric Company
LIBERTY,	Liberty Light and Power Company
LITTLE FALLS,	Herkimer County Light and Power Company
LOCKPORT,	Lockport Gas and Electric Light Company
LONG ISLAND CITY,	New York and Queens Electric Light and Power Company
LYONS,	Wayne County Electric Company
MOUNT VERNON,	Westchester Lighting Company
NEW BRIGHTON,	Richmond Light and Railroad Company
NEWBURGH,	Newburgh Light, Heat and Power Company
NEW YORK CITY,	The New York Edison Company
	The United Electric Light and Power Company
NIAGARA FALLS,	Buffalo and Niagara Falls Electric Light and Power Company
	The Niagara Falls Hydraulic Power and Manufacturing Company
	The Niagara Falls Power Company
NORWICH,	The Norwich Gas and Electric Company
NYACK,	Rockland Light and Power Company
ONEIDA,	Madison County Gas and Electric Company
ONEONTA,	Oneonta Light and Power Company
OSSINING,	Northern Westchester Lighting Company
OVID,	Ovid Electric Company
PEEKSKILL,	Peekskill Lighting and Railroad Company
PORT JERVIS,	Port Jervis Electric Light, Power, Gas and Railroad Company
POTSDAM,	The Potsdam Electric Light and Power Company
POUGHKEEPSIE,	Poughkeepsie Light, Heat and Power Company

NEW YORK—*Continued*

RICHFIELD SPRINGS,	Richfield Springs Electric Light and Power Company
ROCHESTER,	Rochester Railway and Light Company
ROSLYN,	Nassau Light and Power Company
SARANAC LAKE,	Saranac Lake Light, Heat and Power Company
SCHENECTADY,	Schenectady Railway Company
SYRACUSE,	Syracuse Lighting Company
TONAWANDA,	Tonawanda Power Company
TUXEDO PARK,	Tuxedo Electric Light Company
UTICA,	Utica Gas and Electric Company
WATERTOWN,	Watertown Electric Light Company

NORTH CAROLINA

ASHEVILLE,	Asheville Electric Company
CHARLOTTE,	Catawba Power Company
DURHAM,	Durham Traction Company
HENDERSON,	Henderson Lighting and Power Company
RALEIGH,	The Raleigh Electric Company
WINSTON-SALEM,	The Fries Manufacturing and Power Company

NORTH DAKOTA

GRAND FORKS,	Grand Forks Gas and Electric Company
MINOT,	Minot Light and Telephone Company

OHIO

AKRON,	The Northern Ohio Traction and Light Company
ALLIANCE,	The Alliance Gas and Electric Company
BARNESVILLE,	Barnesville Gas and Electric Light Company
CANTON,	Canton Light, Heat and Power Company
CINCINNATI,	The Cincinnati Gas and Electric Company
CLEVELAND,	The Cleveland Electric Illuminating Company
COLUMBUS,	Columbus Railway and Light Company
DEFIANCE,	People's Gas and Electric Company
ELYRIA,	Citizens' Gas and Electric Company
LANCASTER,	Lancaster Electric Light Company
LEIPSIC,	Leipsic Electric Light, Heat and Power Company
LIMA,	The Lima and Toledo Traction Company
LISBON,	The New Lisbon Gas Company
MASSILLON,	The Massillon Light, Heat and Power Company
PORTSMOUTH,	Portsmouth Street Railroad and Light Company
SALEM,	Salem Electric Light and Power Company
SPRINGFIELD,	The People's Light, Heat and Power Company
STEUBENVILLE,	Steubenville Traction and Light Company
TOLEDO,	The Toledo Railways and Light Company
WARREN,	The Warren Water and Light Company
YOUNGSTOWN,	Youngstown Consolidated Gas and Electric Company
ZANESVILLE,	The Zanesville Railway, Light and Power Company

OKLAHOMA

GUTHRIE,	The Guthrie Light and Power Company
SHAWNEE,	Shawnee Light and Power Company

ONTARIO

LONDON,	The London Electric Company, Limited
NIAGARA FALLS,	The Ontario Power Company of Niagara Falls
OTTAWA,	The Ottawa Electric Company
SAULT STE. MARIE,	Tagona Water and Light Company
TORONTO,	Toronto and Niagara Power Company

OREGON

ASHLAND,	Ashland Electric Power and Light Company
BAKER CITY,	Baker Light and Power Company
PORTLAND,	Portland General Electric Company
SALEM,	Citizens' Light and Traction Company

PENNSYLVANIA

ALTOONA,	The Edison Electric Illuminating Company of Altoona
ARDMORE,	Merion and Radnor Gas and Electric Company
BETHLEHEM,	The Bethlehem Electric Light Company
BRADFORD,	Bradford Electric Light and Power Company
CARBONDALE,	Lackawanna Valley Electric Light and Power Supply Company
CARLISLE,	The Carlisle Gas and Water Company
CONNELLSVILLE,	The Electric Company
CONSHOHOCKEN,	Conshohocken Electric Light and Power Company
DANVILLE,	Standard Electric Light Company
DOYLESTOWN,	Doylestown Electric Company
EASTON,	Easton Gas and Electric Company
FRANKLIN,	Franklin Electric Company
GREENVILLE,	People's Electric Light, Heat and Power Company
JERSEY SHORE,	Jersey Shore Electric Company
LEWISTOWN,	Lewistown Electric Light Company
MORTON,	Faraday Heat, Power and Light Company
NEW CASTLE,	New Castle Electric Company
NORRISTOWN,	Norristown Electric Light and Power Company
OIL CITY,	Citizens' Light and Power Company
PHILADELPHIA,	The Electric Company of America
	The Philadelphia Electric Company
	United Gas Improvement Company
PHILIPSBURG,	The Philipsburg Electric Light, Gas, Power and Heating Company
PHŒNIXVILLE,	Schuykill Valley Illuminating Company
PITTSBURGH,	The Allegheny County Light Company
PITTSTON,	Citizens' Electric Illuminating Company
READING,	Metropolitan Electric Company
RENOVO,	Renovo Edison Light, Heat and Power Company

PENNSYLVANIA—*Continued*

SCRANTON,	Scranton Illuminating, Heat and Power Company
TOWANDA,	Towanda Electric Illuminating Company
TYRONE,	Home Electric Light and Steam Heating Company
WARREN,	Warren Electric Light Company
WASHINGTON,	The Washington Electric Light and Power Company
WAYNESBORO,	Waynesboro Electric Light and Power Company
WAYNESBURG,	Waynesburg Electric Light and Power Company
WEST CHESTER,	The Edison Electric Illuminating Company
WILKES-BARRE,	Wilkes-Barre Gas and Electric Company
WILLIAMSPORT,	Lycoming Electric Company
YORK,	Edison Electric Light Company

QUEBEC

MONTREAL,	Montreal Light, Heat and Power Company
QUEBEC,	Quebec-Jacques Cartier Electric Company
	Quebec Railway, Light and Power Company
SHERBROOKE,	The Sherbrooke Power, Light and Heat Company

RHODE ISLAND

NEWPORT,	Newport and Fall River Street Railway Company
PAWTUCKET,	Pawtucket Electric Company
PROVIDENCE,	Narragansett Electric Lighting Company
WOONSOCKET,	Woonsocket Electric Machine and Power Company

SOUTH CAROLINA

CHARLESTON,	Charleston Consolidated Railway, Gas and Electric Company
COLUMBIA,	Columbia Electric Street Railway, Light and Power Company
DARLINGTON,	Darlington Light and Water Company
GEORGETOWN,	Georgetown Electric Company

SOUTH DAKOTA

LEAD,	Consolidated Power and Light Company

TENNESSEE

BRISTOL,	Bristol Gas and Electric Company
CHATTANOOGA,	Chattanooga Electric Company
COLUMBIA,	Columbia Water and Light Company
KNOXVILLE,	Knoxville Railway and Light Company
MEMPHIS,	Memphis Consolidated Gas and Electric Company
NASHVILLE,	Nashville Railway and Light Company

TEXAS

Beaumont,	Beaumont Ice, Light and Refrigerating Company
Cleburne,	The Cleburne Gas and Electric Company
Corsicana,	Corsicana Gas and Electric Company
Dallas,	Dallas Electric Light and Power Company
	Dallas Ice Factory, Light and Power Company
El Paso,	El Paso Electric Railway Company
Gainesville,	Merchants' Electric Light and Power Company
Houston,	Houston Lighting and Power Company
Marshall,	Arkansas and Texas Consolidated Ice and Coal Company
Paris,	Paris Light and Power Company
San Antonio,	San Antonio Gas and Electric Company
Taylor,	Taylor Electric Light Company
Waxahachie,	Waxahachie Gas and Electric Company
Weatherford,	City of Weatherford Water, Light and Ice Company

UTAH

Eureka,	Eureka Electric Company
Salt Lake City,	Utah Light and Railway Company

VERMONT

Bellows Falls,	The Fall Mountain Electric Light and Power Company
Bennington,	Bennington Electric Company
Brandon,	Neshobe Electric Company
Burlington,	Burlington Light and Power Company
Fair Haven,	Fair Haven Electric Company
Middlebury,	Middlebury Electric Company
Montpelier,	Consolidated Lighting Company
Rutland,	Rutland City Electric Company
St. Johnsbury,	St. Johnsbury Electric Company
Vergennes,	Vergennes Electric Company

VIRGINIA

Lynchburg,	Lynchburg Traction and Light Company
Richmond,	Virginia Passenger and Power Company
Roanoke,	Roanoke Railway and Electric Company

WASHINGTON

Aberdeen,	Gray's Harbor Electric Company
Everett,	Everett Railway, Light and Water Company
North Yakima,	Northwest Light and Water Company
Olympia,	Olympia Light and Power Company
Seattle,	Seattle-Tacoma Power Company
	The Seattle Electric Company
Spokane,	The Washington Water Power Company
Walla Walla,	Northwestern Gas and Electric Company

WEST VIRGINIA

BLUEFIELD,	East River Electric Company
CHARLESTON,	Kanawha Water and Light Company
FAIRMONT,	Fairmont and Clarksburg Traction Company
PARKERSBURG,	Parkersburg, Marietta and Inter-Urban Railway Company
SISTERSVILLE,	Sistersville Electric Light and Power Company
WELCH,	Welch Water, Light and Power Company
WHEELING,	The Wheeling Electrical Company

WISCONSIN

ANTIGO,	Antigo Electric Light Plant
DELAVAN,	Delavan Light and Fuel Company
EAU CLAIRE,	Eau Claire Light and Power Company
FOND-DU-LAC,	Eastern Wisconsin Railway and Light Company
JANESVILLE,	Janesville Electric Company
KENOSHA,	Kenosha Gas and Electric Company
LA CROSSE,	La Crosse Gas and Electric Light Company
MADISON,	Madison Gas and Electric Company
MENOMONIE,	Menomonie Electric Light and Power Company
MERRILL,	Merrill Railway and Lighting Company
OCONTO,	W. A. Holt
OSHKOSH,	Oshkosh Gas Light Company
PORT WASHINGTON,	The Wisconsin Chair Company
RHINELANDER,	Rhinelander Lighting Company
SHEBOYGAN,	Sheboygan Light, Power and Railway Company
SPARTA,	O. I. Newton's Sons Company
WATERTOWN,	Watertown Gas and Electric Company
WAUKESHA,	Waukesha Gas and Electric Company
WAUPACA,	Waupaca Electric Light and Railway Company
WAUSAU,	Wausau Electric Company

WYOMING

CHEYENNE,	Cheyenne Light, Fuel and Power Company
GREEN RIVER,	Green River Electric Light and Power Company
RAWLINS,	The Rawlins Electric Light and Fuel Company
SHERIDAN,	The Sheridan Electric Light and Power Company

YUKON TERRITORY

WHITE HORSE,	The Yukon Electrical Company, Limited

MEMBERS—CLASS B

Akins, Sage, Lewiston-Clarkston Company, Asotin, Wash.
Allegaert, Edgar J., Public Service Corporation of New Jersey, Newark, N. J.
Anderson, C., Public Service Corporation of New Jersey, Hackensack, N. J.
Atkins, Wm. H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Bache, R. P., Public Service Corporation of New Jersey, Plainfield, N. J.
Baehr, Wm. A., Laclede Gas Light Company., St. Louis, Mo.
Ballard, R. H., The Edison Electric Company, Los Angeles, Calif.
Bechtel, E. J., Toledo Railways and Light Company, Toledo, Ohio.
Belcher, Walter A., Public Service Corporation of New Jersey, Perth Amboy, N. J.
Bement, A., Chicago Edison Company, Chicago, Ill.
Bishop, Jas. W., The Peninsular Electric Light Company, Detroit, Mich.
Black, A. L., New Orleans and Carrollton Railroad, Light and Power Company, New Orleans, La.
Blood, W. H., Jr., Seattle Electric Company, Boston, Mass.
Brock, Wm. M., Public Service Corporation of New Jersey, Paterson, N. J.
Brockway, W. B., Nashville Railway and Light Company, Yonkers, N. Y.
Brown, Crawford R., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Bump, Milan R., Denver Gas and Electric Company, Denver, Colo.
Bushnell, O. J., Chicago Edison Company, Chicago, Ill.
Caldwell, Eliot L., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Campbell, Alex. J., New London Gas and Electric Company, New London, Conn.
Cato, George W., The Peninsular Electric Light Company, Detroit, Mich.
Chandler, H. P., Public Service Corporation of New Jersey, Newark, N. J.
Claflin, George E., Omaha Electric Light and Power Company, Boston, Mass.
Clark, Robert J., Colorado Springs Electric Company, Colorado Springs, Colo.
Cobb, B. C., Bartlett Illuminating Company, Saginaw, Mich.
Colby, Leroy S., Lawrence Gas Company, Lawrence, Mass.
Collins, W. Ben., Lake Charles Ice, Light and Water Works Company, Lake Charles, La.
Cowles, J. E., Hot Springs Water Company, Hot Springs, Ark.
Cowles, J. W., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Curtis, S. P., Burlington Light and Power Company, Burlington, Vt.
Cushman, G. H., San Antonio Gas and Electric Company, San Antonio, Tex.
Davis, Ernest H., Lycoming Electric Company, Williamsport, Pa.
Deal, E. C., Public Service Corporation of New Jersey, Hackensack, N. J.

Dillon, E. P., Colorado Springs Electric Company, Colorado Springs, Colo.
Doherty, Henry L., The Denver Gas and Electric Company, New York City.
Edgar, Charles L., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Eglin, Wm. C. L., Philadelphia Electric Company, Philadelphia, Pa.
Elden, Leonard L., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Elliott, J. G., Public Service Corporation of New Jersey, Newark, N. J.
Emery, James A., Birmingham Railway, Light and Power Company, Birmingham, Ala.
Farrand, Dudley, Public Service Corporation of New Jersey, Newark, N. J.
Francis, W. H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
French, Edward R., Public Service Corporation of New Jersey, Elizabeth, N. J.
Frueauff, Frank W., Denver Gas and Electric Company, Denver, Colo.
Fuller, George A., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Gaffney, John J., Public Service Corporation of New Jersey, Newark, N. J.
Gardiner, W. H., Jr., Boston Consolidated Gas Company, Boston, Mass.
Goettling, Gerhard M. W., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Goodale, Roy Lewis, Colorado Springs Electric Company, Colorado Springs, Colo.
Greacen, W., Jr., Public Service Corporation of New Jersey, Hoboken, N. J.
Hammack, H. A., Montgomery Light and Water Power Company, Montgomery, Ala.
Hancock, W. P., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Harris, C. G., Key West Electric Company, Key West, Fla.
Hatch, Charles J., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Herrick, Charles H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Hess, Paul A., Lycoming Electric Company, Williamsport, Pa.
Hires, B. F., Bridgeton Electric Company, Bridgeton, N. J.
Hodskinson, Charles H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Holberton, George C., Oakland Gas Light and Heat Company, Oakland, Calif.
Hosmer, Sidney, The Edison Electric Illuminating Company of Boston, Boston, Mass.
Howell, David J., Welch Water, Light and Power Company, Washington, D. C.
Humphrey, C. J. R., Lawrence Gas Company, Lawrence, Mass.
Hurtz, Leonard E., Lincoln Gas and Electric Light Company, Lincoln, Nebr.
Ingalls, Percy, Public Service Corporation of New Jersey, Newark, N. J.

Insull, Fred. W., North Shore Electric Company, Evanston, Ill.
Insull, Samuel, Chicago Edison Company, Chicago, Ill.
Jackson, W. B., Janesville Electric Company, Madison, Wis.
Johann, Charles S., The People's Light, Heat and Power Company, Springfield, Ohio.
Johnson, Walter H., Philadelphia Electric Company, Philadelphia, Pa.
Keeler, J. P., Asheville Electric Company, Asheville, N. C.
Kennedy, D., Colorado Springs Electric Company, Colorado Springs, Colo.
Kent, E. G., Public Service Corporation of New Jersey, Jersey City, N. J.
Kibbe, A. S., Home Electric Light and Steam Heating Co., Philadelphia, Pa.
King, H. D., Public Service Corporation of New Jersey, Hoboken, N. J.
Leigh, Albert, Fall River Electric Light Company, Fall River, Mass.
Lewis, W. M., Public Service Corporation of New Jersey, East Somerville, N. J.
Lieb, J. W., Jr., The New York Edison Company, New York City.
Littell, H. M., San Antonio Gas and Electric Company, San Antonio, Tex.
Little, Francis W., Peoria Gas and Electric Company, Peoria, Ill.
Lloyd, E. W., Chicago Edison Company, Chicago, Ill.
Lukes, Geo. H., North Shore Electric Company, Evanston, Ill.
Lüpke, Paul, Public Service Corporation of New Jersey, Trenton, N. J.
Lynch, A. H., Public Service Corporation of New Jersey, Morristown, N. J.
Manwaring, A. H., Philadelphia Electric Company, Philadelphia, Pa.
McCall, Jos. B., Philadelphia Electric Company, Philadelphia, Pa.
McCarthy, J. M., Quebec-Jacques Cartier Electric Company, Quebec, Canada.
McCoy, W. E., The United Electric Light and Power Company, New York City.
McDonald, W. B., Evansville Gas and Electric Light Company, Evansville, Ind.
McFeeley, Jno., Public Service Corporation of New Jersey, Bristol, Pa.
Miller, John B., The Edison Electric Company, Los Angeles, Calif.
Moore, J. L., Public Service Corporation of New Jersey, Camden, N. J.
Moultrop, Irving E., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Murphy, John, Ottawa Electric Company, Ottawa, Ontario.
Niesz, Homer E., Chicago Edison Company, Chicago, Ill.
Nunn, Josiah J., Telluride Power Company, Provo, Utah.
Nunn, P. N., Telluride Power Company, Niagara Falls, N. Y.
Parker, Charles H., The Edison Electric Illuminating Company of Boston, Boston, Mass.
Partridge, Warren, Public Service Corporation of New Jersey, Orange, N. J.
Peck, Edward F., Schenectady Illuminating Company, Schenectady, N. Y.
*Peters, Chas. H., Durango Light and Power Company, Durango, Colo.
Plummer, H. W., Asheville Electric Company, Asheville, N. C.

* Deceased.

Power, W. R., Home Electric Light and Steam Heating Company, Tyrone, Pa.

Purcell, Thos. E., Billings Water Power Company, Billings, Mont.

Reesman, John S., North Shore Electric Company, Highland Park, Ill.

Richards, E. J., Newburgh Light, Heat and Power Company, Newburgh, N. Y.

Richardson, H. C., Public Service Corporation of New Jersey, Metuchen, N. J.

Rix, Anson F., East River Electric Company, Bluefield, W. Va.

Rogers, W. H., Public Service Corporation of New Jersey, Paterson, N. J.

Scherck, Leon H., Birmingham Railway, Light and Power Company, New York City.

Schmidt, F. W., Public Service Corporation of New Jersey, Jersey City, N. J.

Schwabe, Walter P., Public Service Corporation of New Jersey, Hackensack, N. J.

Sheridan, Sarah M., Peninsular Electric Light Company, Detroit, Mich.

Sherwin, John J., United Light and Power Company, Idaho Springs, Colo.

Smith, F. Ellwood, The Edison Electric Illuminating Company of Boston, W. Somerville, Mass.

Stelling, C. A., Public Service Corporation of New Jersey, Passaic, N. J.

Stevens, E. H., Public Service Corporation of New Jersey, Newark, N. J.

Sullivan, R. B., Denver Gas and Electric Company, Denver, Colo.

Thompson, Wright B., Peninsular Electric Light Company, Detroit, Mich.

Titzell, W. W., Public Service Corporation of New Jersey, Jersey City, N. J.

Tripp, Geo. B., Colorado Springs Electric Company, Colorado Springs, Colo.

Tuttle, W. B., Consolidated Gas Company, Long Branch, N. J.

Uhlenhart, F. Jr., Allegheny County Light Company, Pittsburgh, Pa.

Urban, O. C. G., Key West Electric Company, Key West, Fla.

Vredenburgh, LaRue, The Edison Electric Illuminating Company of Boston, Boston, Mass.

Wallace, L. M., The Edison Electric Illuminating Company of Boston, Boston, Mass.

Warner, E. N., Billings Water Power Company, Billings, Mont.

Wells, H. H., Public Service Corporation of New Jersey, Orange, N. J.

Wendle, George E., Lycoming Electric Company, Williamsport, Pa.

White W. F., Peninsular Electric Light Company, New York City.

Wilson, John A., Public Service Corporation of New Jersey, Trenton, N. J.

Yawger, Thomas H., Rochester Railway and Light Company, Rochester, N. Y.

Young, O. H., Wabash Water and Light Company, Wabash, Ind.

Young, Percy S., Public Service Corporation of New Jersey, Newark, N. J.

Young, R. R., Public Service Corporation of New Jersey, Passaic, N. J.

MEMBERS—CLASS C

Adams, Comfort A., Harvard University, Cambridge, Mass.
Brown, Charles F., Vanderbilt College, Nashville, Tenn.
Caldwell, Francis C., Ohio State University, Columbus, Ohio.
Comstock, Charles W., 213 Boston Building, Denver, Colo.
Cooper, Frank L., Johns-Hopkins University, Baltimore, Md.
Crain, L. D., State Agricultural College, Fort Collins, Colo.
Dates, Henry B., School of Applied Science, Cleveland, Ohio.
Freedman, W. H., University of Vermont, Burlington, Vt.
Green, Jerome J., University of Notre Dame, Notre Dame, Ind.
Hazard, William J., Colorado School of Mines, Golden, Colo.
Hirokawa, T., Doshisha College, Kyoto, Japan.
Jackson, Dugald C., University of Wisconsin, Madison, Wis.
Kay, Edgar B., University of Alabama, Tuscaloosa, Ala.
Kennelly, A. E., Harvard University, Cambridge, Mass.
Kent, James M., Manual Training High School, Kansas City, Mo.
Kent, William, Syracuse University, Syracuse, N. Y.
Lawrence, Ralph R., Massachusetts Institute of Technology, Boston, Mass.
Lee, Claudius, Virginia Polytechnic Institute, Blacksburg, Va.
Macomber, George Stanley, Sibley College, Cornell University, N. Y.
Magnusson, Carl Edward, University of Washington, Seattle, Wash.
Noble, G. C., University of California, Berkeley, Calif.
Nordstrom, L. D., Purdue University, Lafayette, Ind.
Norris, Henry H., Cornell University, Ithaca, N. Y.
Patten, H. E., University of Wisconsin, Madison, Wis.
Patterson, George W., University of Michigan, Ann Arbor, Mich.
Perrine, Frederic A. C., Polytechnic Institute, Brooklyn, N. Y.
Radtke, A. A., Armour Institute, Chicago, Ill.
Rowland, Arthur J., Drexel Institute, Philadelphia, Pa.
Ryan, Harris J., Cornell University, Ithaca, N. Y.
Sawyer, A. R., Agricultural College, Lansing, Mich.
Shaad, Geo. C., University of Wisconsin, Madison, Wis.
Shaw, H. B., University of Missouri, Columbia, Mo.
Sheldon, Dr. Samuel, Polytechnic Institute, Brooklyn, N. Y.
Shepardson, George D., University of Minnesota, Minneapolis, Minn.
Smith, Harold Babbitt, Worcester Polytechnic Institute, Worcester, Mass.
Smith, Harrison W., Massachusetts Institute of Technology, Boston, Mass.
Swenson, B. B., University of Wisconsin, Madison, Wis.
Thaler, Joseph A., Montana Agricultural College, Bozeman, Mont.
Wilson, Alexander Massey, Kentucky State College, Lexington, Ky.
Wolcott, E. R., Colorado School of Mines, Golden, Colo.

ASSOCIATE MEMBER COMPANIES—CLASS D

AMPERE, N. J.,	Crocker-Wheeler Company
AUBURN, N. Y.,	McIntosh, Seymour and Company
BALTIMORE, MD.,	Electrical Material Company
BANGALORE CITY, BR. INDIA,	B. D. Nath
BOSTON, MASS.,	Albert and J. M. Anderson Manufacturing Company
	American Telephone and Telegraph Company
	Electrical Auditing Company
	Electric Gas Lighting Company
	Frank Ridlon Company
	Herbert S. Potter
	J. S. Codman and Company
	Massachusetts Chemical Company
	McKenney and Waterbury Company
	Pettingell-Andrews Company
	Stuart-Howland Company
	The Simplex Electrical Company
	Thomas C. Wales
BRIDGEPORT, CONN.,	Bryant Electric Company
BUFFALO, N. Y.,	National Battery Company
CHELSEA, MASS.,	American Circular Loom Company
CHICAGO, ILL.,	American Electrical Supply Company
	Chicago Fuse Wire and Manufacturing Company
	Dearborn Drug and Chemical Company
	Electric Appliance Company
	Gregory Electric Company
	The Arnold Company
	Western Electric Company
	Western Electrician
CINCINNATI, OHIO,	Triumph Electric Company
CLEVELAND, OHIO,	Adams-Bagnall Electric Company
	Buckeye Electric Company
	National Carbon Company
COVINGTON, KY.,	Hemingray Glass Company
DAYTON, OHIO,	National Cash Register Company
DETROIT, MICH.,	The Phelps Company
EAST PITTSBURGH, PA.,	The Westinghouse Machine Company
FORT WAYNE, IND.,	Fort Wayne Electric Works
FOSTORIA, OHIO,	Crouse-Tremaine Carbon Company
GREAT BARRINGTON, MASS.,	Stanley Instrument Company

JONESBORO, IND.,	Indiana Rubber and Insulated Wire Company
KEOKUK, IA.,	Garton-Daniels Company
LOCKPORT, N. Y.,	American District Steam Company
MATTEAWAN, N. Y.,	The Green Fuel Economizer Company
MILWAUKEE, WIS.,	Allis-Chalmers Company
	National Electric Company
NEWARK, N. J.,	Baker and Company
	Weston Electrical Instrument Company
NEW BEDFORD, MASS.,	W. S. Hill Electric Company
NEWBURYPORT, MASS.,	Chase-Shawmut Company
NEW YORK CITY,	Alberger Condenser Company
	American-Diesel Engine Company
	American Vitrified Conduit Company
	Association of Licensed Manufacturers of Incandescent Lamps
	Atlantic Insulated Wire and Cable Company
	Bryan-Marsh Company
	Converse D. Marsh
	De La Vergne Machine Company
	Electrical Review Publishing Company
	Electrical Testing Laboratories
	Electricity Newspaper Company
	Ford, Bacon and Davis
	Franklin H. Kalbfleisch Company
	General Electric Company
	Gould Storage Battery Company
	H. B. Camp Company
	Holophane Glass Company
	Hugo Reisinger
	H. W. Johns-Manville Company
	India Rubber and Gutta Percha Insulating Company
	International Steam Pump Company
	Jeremiah J. Kennedy
	J. G. White Company
	J. Henry Hallberg
	John A. Roebling's Sons Company
	Manhattan Electrical Supply Company
	McGraw Publishing Company
	National Conduit and Cable Company
	New York Insulated Wire Company
	Osburn Flexible Conduit Company
	Rossiter, MacGovern and Company
	Sanderson and Porter
	Sprague Electric Company
	Standard Vitrified Conduit Company
	The *Cassier Magazine* Company

New York City,	The *Central Station*
	The Dale Company
	The Okonite Company, Limited
	The Phœnix Glass Company
	The Standard Paint Company
Philadelphia, Pa.,	Alfred F. Moore
	Electric Storage Battery Company
	James H. Dawes
Pittsburgh, Pa.,	Doubleday-Hill Electric Company
	Nernst Lamp Company
	Standard Underground Cable Company
	The Pittsburgh Reduction Company
	Westinghouse Electric and Manufacturing Company
Pittsfield, Mass.,	Stanley Electric Manufacturing Company
Providence, R. I.,	American Electrical Works
	New England Butt Company
St. Louis, Mo.,	Columbia Incandescent Lamp Company
	The Emerson Electric Manufacturing Company
	Wagner Electric Manufacturing Company
South Bend, Ind.,	George Cutter Company
Springfield, Mass.,	Munder Electrical Works
Syracuse, N. Y.,	Crouse-Hinds Electric Company
	Pass and Seymour
Trenton, N. J.,	De Laval Steam Turbine Company
Utica, N. Y.,	Frank G. Scofield
Warren, Ohio,	New York and Ohio Company
West New Brighton, N.Y.,	C. W. Hunt Company
Worcester, Mass.,	American Steel and Wire Company

ASSOCIATE MEMBERS—CLASS E

Addison, Dr. Thomas, General Electric Company, San Francisco, Calif.
Babson, A. D., General Electric Company, New York City.
Barbour, F. F., General Electric Company, San Francisco, Calif.
Barr, J. M., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Beran, T., General Electric Company, New York City.
Boyer, F. N., General Electric Company, Chicago, Ill.
Brady, Paul T., Westinghouse Electric and Manufacturing Company, Syracuse, N. Y.
Buddy, H. C., General Electric Company, Philadelphia, Pa.
Bullen, D. R., General Electric Company, Schenectady, N. Y.
Burleigh, Chas. G., General Electric Company, Boston, Mass.
Clark, Wallace S., General Electric Company, Schenectady, N. Y.
Clegg, William, Jr., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Cook, C. S., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Davis, C. B., General Electric Company, Boston, Mass.
Davis, H. P., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Emmet, W. L. R., General Electric Company, Schenectady, N. Y.
Emmons, E. E., General Electric Company, Schenectady, N. Y.
Feicht, R. S., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Felton, J. P., General Electric Company, Boston, Mass.
Fish, W. C., General Electric Company, West Lynn, Mass.
Fowler, W. F., Westinghouse Electric and Manufacturing Company, Baltimore, Md.
Gale, F. H., General Electric Company, Schenectady, N. Y.
Gaylord, T. P., Westinghouse Electric and Manufacturing Company, Chicago, Ill.
Gilbert, E. E., General Electric Company, Schenectady, N. Y.
Giles, A. F., General Electric Company, Atlanta, Ga.
Gordon, W. R., Westinghouse Electric and Manufacturing Company, Atlanta, Ga.
Griffin, G. B., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Griffin, General Eugene, General Electric Company, New York City.
Hale, General Irving, General Electric Company, Denver, Colo.
Harris, Max, Nernst Lamp Company, Pittsburgh, Pa.
Haskins, C. D., General Electric Company, Schenectady, N. Y.
Hillman, H. W., General Electric Company, Schenectady, N. Y.

Houck, H. C., General Electric Company, Cincinnati, Ohio.
Humphrey, C. B., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Hunting, F. S., Fort Wayne Electric Works, Fort Wayne, Ind.
Knox, King H., Bullock Electric Manufacturing Company, Cincinnati, Ohio.
Lamme, R. G., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Lovejoy, J. R., General Electric Company, Schenectady, N. Y.
Manson, D. E., Westinghouse Electric and Manufacturing Company, Boston, Mass.
McConney, R. B., Allis-Chalmers Company, Denver, Colo.
Mullen, E. D., General Electric Company, Philadelphia, Pa.
Nicholson, S. L., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Page, A. D., General Electric Company, Harrison, N. J.
Panteleoni, G., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Pevear, J. B., General Electric Company, Cincinnati, Ohio.
Randall, K. C., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Rice, E. W., General Electric Company, Schenectady, N. Y.
Rice, R. H., General Electric Company, West Lynn, Mass.
Roberts, E. R., Nernst Lamp Company, Pittsburgh, Pa.
Rugg, W. S., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Scott, Chas. F., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Scribner, J., General Electric Company, Chicago, Ill.
Serva, A. A., Fort Wayne Electric Works, Fort Wayne, Ind.
Steinmetz, C. P., General Electric Company, Schenectady, N. Y.
Stone, C. W., General Electric Company, Schenectady, N. Y.
Sunny, B. E., General Electric Company, Chicago, Ill.
Taylor, Frank H., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Thompson, G. L., General Electric Company, Philadelphia, Pa.
Tingley, E. M., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Vaughen, F. G., General Electric Company, Schenectady, N. Y.
Wagoner, P. D., General Electric Company, Schenectady, N. Y.
Warner, R. L., Westinghouse Electric and Manufacturing Company, Boston, Mass.
Warren, Arthur, Allis-Chalmers Company, Milwaukee, Wis.
Whiteside, W. H., Allis-Chalmers Company, Chicago, Ill.
Wiley, James R., Standard Underground Cable Company, Chicago, Ill.
Willcox, Francis W., General Electric Company, Harrison, N. J.
Wirt, H. C., General Electric Company, Schenectady, N. Y.
Wood, James J., Fort Wayne Electric Works, Fort Wayne, Ind.

OFFICERS AND EXECUTIVE COMMITTEE

Officers

Ernest H. Davis	President
Wm. H. Blood, Jr.,	First Vice-President
Arthur Williams	Second Vice-President
Dudley Farrand	Secretary and Treasurer
H. Billings	Asst. Secretary and Treasurer
George F. Porter	Master of Transportation

Executive Committee

Elected at the Twenty-fifth to serve until the close of the Twenty-eighth Convention

A. C. Dunham P. G. Gossler
H. T. Hartman

Elected at the Twenty-sixth to serve until the close of the Twenty-ninth Convention

Louis A. Ferguson Harry Bottomley
Alex Dow

Elected at the Twenty-seventh to serve until the close of the Thirtieth Convention

Samuel Scovil A. J. De Camp
W. F. White

COMMITTEES

TO REPORT TO THE TWENTY-EIGHTH CONVENTION

Committee on Standard Rules for Electrical Construction and Operation

CHARLES L. EDGAR, Chairman

P. G. GOSSLER
WILLIAM BROPHY
ALEX DOW
SAMUEL SCOVIL

Committee on Fuel Economies

HENRY L. DOHERTY, Chairman

W. L. ABBOTT
DUGALD C. JACKSON

Committee on Relations Between Manufacturers and Central Stations

HENRY L. DOHERTY, Chairman

A. C. DUNHAM
LOUIS A. FERGUSON

Committee on Relations with Kindred Organizations

JAMES I. AYER, Chairman

ARTHUR WILLIAMS
HENRY E. CLIFFORD

Committee for Investigation of Steam Turbines

W. C. L. EGLIN, Chairman

A. C. DUNHAM
IRVING E. MOULTROP
GEORGE W. CATO
J. D. ANDREW

Committee on District Heating

W. H. BLOOD, JR., Chairman

C. R. MAUNSELL
R. S. WALLACE

Committee on Present Methods of Protection from Lightning and Other Static Disturbances

ALEX DOW, Chairman

ROBERT STUART STEWART

Committee on Rates and Costs

CHARLES L. EDGAR, Chairman

LOUIS A. FERGUSON
SAMUEL SCOVIL
FRANK W. FRUEAUFF
P. G. GOSSLER
GEO. W. BRINE
R. S. HALE

Reporter on Advertising Methods	PERCY INGALLS
Reporter on Decorative and Sign Lighting	LARUE VREDENBURGH
Reporter on Purchased Electric Power in Factories	E. W. LLOYD
Reporter on Progress of Electric Heating	JAMES I. AYER
Reporter on Municipal Ownership	ARTHUR WILLIAMS
Editor of Progress	T. COMMERFORD MARTIN
Editor Wrinkle Department	H. C. ABELL
Editor Question Box	HOMER E. NIESZ

ORDER OF BUSINESS

TUESDAY, June 6, 1905.

FIRST SESSION, 10.30 A. M.

1. Address of Mayor Speer
2. Announcements
3. Address of President Davis
4. Report—Committee on Progress. T. COMMERFORD MARTIN, Reporter
5. Report—The Tantalum Incandescent Lamp. DR. LOUIS BELL
6. Paper—"The Paramount Importance of the Selection of Standard in Preference to Special Machinery." By DAVID HALL
7. Paper—"Insulation Testing—Apparatus and Methods." By C. E. SKINNER

SECOND SESSION, 2.30 P. M.

1. Paper—"Automatic Synchronizing of Generators and Rotaries." By PAUL MACGAHAN
2. Paper—"Notes on Rotary Converters and Motor-Generators for Lighting and Power Systems." By LOUIS E. BOGEN
3. Discussion of Report on Progress
4. Paper—"The Organization of Working Forces in Large Power-Houses." By W. P. HANCOCK
5. Report—Committee for the Investigation of the Steam Turbine. WM. C. L. EGLIN, Chairman
6. Paper—"Operating Features of Vertical Curtis Steam Turbines." By A. H. KRUESI

MINUTES

OPENING OF THE CONVENTION

The twenty-eighth convention of the National Electric Light Association was held at Denver and Colorado Springs, June 6, 7, 8, 9, 10 and 11, 1905. The business sessions were held at the Brown Palace Hotel, Denver, June 6, 7 and 8. The meeting was called to order by President Davis at half after ten o'clock, Tuesday morning, June 6. The first order of business was the address of welcome. President Davis introduced the Hon. Robert W. Speer, mayor of the city of Denver, who delivered the following address:

ADDRESS OF MAYOR SPEER

Mr. President and Members of the National Electric Light Association:

It is a pleasure for me to welcome such a representative body of men to this city. When we learned that your convention was to be held here we were pleased, because we believed that you could do us good and that by meeting and becoming acquainted with the warm-hearted western people your views and opinions of the great West would be enlarged. We have a city that is new. It lacks many of the ornaments that are pleasing to the eye, yet we are laying a good foundation and we are going to build Denver so that it will be known all over this country for beauty and business combined. There is no city in the West, or in any part of the United States, where the people are more loyal and enthusiastic than in Denver. There is no state with greater possibilities than Colorado. It extends about 300 miles from north to south and 400 miles from east to west—an empire in itself. We take from the hills over two million dollars' worth of gold every thirty days. We have more coal—lignite, bituminous and anthracite—than the great state of Pennsylvania. We have exceedingly large products of silver, lead, zinc and copper. Our cattle on the ranges in northwestern Colorado feed with the elk and the deer. Our sugar-beet industry is new, and yet it will this year exceed any other state in the Union in production. You will notice that I have been asked, in saying a few words to you, to "boost" Denver and Colorado.

I want to ask you if you have heard of our Greeley potatoes, our Colorado celery, our Grand Junction peaches, our Cañon City strawberries and our Rocky Ford melons. We have altitudes here from about 4000 to 15,000 feet. You can stay down where it is warm or you can go up where you can snowball any day in the year. From experience, our agriculturists and fruit raisers are learning that there is a certain altitude and certain soil where they can raise the best wheat and potatoes, the sweetest melons and peaches, and as we shall store this water that is running to waste, and hold it back until we need it, we shall

make Colorado's barren places blossom as a rose. But our climate is an asset greater than our mines, our farms and our ranches. Tribute is paid to it from every state in the Union. You are to-day one mile above the level of the sea. You feel our altitude, yet you enjoy our cool nights, and if you remain long enough you will find that the change will do you good. I came here, over twenty years ago, a consumptive from Pennsylvania. My father, brother and sister died of lung trouble. I had hemorrhages and was confined to my bed six weeks at a time. I attended school in Williamsport, that beautiful little city where the president of your association resides. My physician said, "Colorado is your only hope." I came here and purchased a team in Denver and started out. For two years I roughed it and lived out of doors; spent my summers in the mountains, driving south into New Mexico during the winter. During the summer I lived in an altitude where when we killed a deer it remained sweet and pure for weeks at a time. We had a rope and pulley that we fastened near the top of a tree. We covered the deer with a piece of gunny sack to keep off the flies, then drew it up into the pure air. It would harden and dry a little on the outside, but would remain sweet and pure for weeks. The air in which you can keep meat fresh all during the summer will stop decay of the lungs, and by out-door life they will be fully restored. Our bright sunny days the whole year round, our pure air and our cool nights, have given the bloom of health to many sad, pinched faces.

In Colorado we all boast. We can not help it—it is in the air. If any of you gentlemen are looking for a change of location—if you want to start in and personally help in developing and opening up the wonderful resources of this new empire; if you have money to invest and want to place it where it will be safe and will give sure returns; if your health is failing, or you feel that you are breaking down under the strain and cares of business—turn toward Denver and Colorado.

In behalf of the men and women of this city I want to extend to you the hand of hospitality, the freedom of our city; good wishes and kind thoughts for your comfort and happiness while here and for a longing to return after you go away. Gentlemen, Denver is yours; the gate is now wide open—walk in and help yourselves.

THE PRESIDENT: Gentlemen, I am sure we all appreciate the hearty welcome extended to us by Mayor Speer. The good things he has said about Denver in his address are some of the reasons that induced us to select Denver as our place of meeting. We thought it would be a good idea, and would be an education for many of our members, to come West, and after listening to the eloquent remarks of the mayor and anticipating the pleasant experiences we shall have during our stay in Colorado, I am sure we have made no mistake in selecting Denver-Colorado Springs as our place of meeting.

I wish to thank Mayor Speer, on behalf of the association, for his address of welcome.

ANNOUNCEMENTS

Secretary Farrand announced that the following-named gentlemen had communicated their regret at being unable to attend the meeting:

Past-President Samuel Duncan, Atlanta, Ga.
Past-President Edwin R. Weeks, Kansas City, Mo.
Past-President Edward A. Armstrong, Camden, N. J.
Past-President James B. Cahoon, New York City
Past-President Charles L. Edgar, Boston, Mass.
P. G. Gossler, New York City, Member of the Executive Committee
Dr. Edward L. Nichols, Cornell University, Honorary Member
Elihu Thomson, Lynn, Mass., Honorary Member
George D. Forbes, London, England, Honorary Member
Charles F. Brush, Cleveland, Ohio, Honorary Member
Professor Henry T. Bovey, McGill University, Honorary Member

ADDRESS OF PRESIDENT DAVIS

To the Members of the National Electric Light Association:

For the first time in the history of the National Electric Light Association, its annual convention will be held west of the Missouri River, and no more typical city of the West could have been selected than the progressive municipality of Denver, nor any more beautiful spot than Colorado Springs. The choice of our place of meeting was a tribute to the development of the central-station industry throughout the West and was intended to bring our western members in closer touch with the work and objects of the association and to secure closer personal relations among our members from all sections of the country. The present convention may therefore be termed somewhat missionary in its object. The membership of the association becomes perceptibly smaller as we go westward, and it is expected that the Denver-Colorado Springs meeting will result in a large increase in our membership from the West. The state of Colorado is, however, an exception, in that an unusually large proportion of the central stations located within its borders are already members of the association.

In this connection, it will not be amiss to refer briefly to the work done by the association in recent years. The annual conventions offer the only general opportunity for a personal exchange of thought and experience among a large number of central-station managers, as well as for the presentation of papers and discussions on matters of general interest. But the field of the association is far broader than the benefit derived from such personal exchange of individual views and the reading of papers and discussions founded thereon.

The interests of the central station considered as an industry are what have lately received the best thought and work of your association, the vital questions being no longer preeminently those of management or type of plant, but rather those relating to the stability and legitimate earning power of the industry.

The one great and constant menace to the industry is

unwise, burdensome and restrictive legislation by the municipality and the state. The right to tax is the power to destroy. The power to regulate contains the germ of the danger of confiscation, in whole or in part. The regulation of the industry by a commission with powers such as are vested in the Gas and Electric Light Commission of the state of Massachusetts may be proper and satisfactory as safeguarding the rights of both the public and the investor. But regulation by a commission brought into being by a manufactured public sentiment, and having its inception in politics, not primarily or honestly intended to remedy any admitted public oppression or to properly regulate the use of public franchises, can not be fair either to the public or to the investor and must result in gross injustice to the industry.

The association should not be passive while laws placing the industry under the regulation of commissions are passed by the several states, without making proper suggestions whereby such laws would be made reasonable and uniform in their provisions. Nor should it permit, without protest, the passage of any laws admittedly unduly restrictive and burdensome. The object should be to have the general laws of the several states relating to the industry conform to some standard, fair both to the public and to the industry.

For one state to grant only very limited term franchises under burdensome restrictions and for another—and possibly an adjoining state—to grant perpetual franchises without restrictions; for one state to reserve the right to fix and change the rate of charge for service rendered and for another state to empower any municipality to make any rate it may see fit and to change the same when and as it pleases—can not but injuriously affect the stability of the industry from the standpoint of the investing public.

I would therefore recommend the appointment of a standing committee on legislation, to aid in protecting the interests of our members should occasion arise.

The formation of state or sectional associations, whose object it shall be to call the attention of the interests affected to proposed legislation and to secure concert of action for mutual protection, should be encouraged. Such associations could very advantageously act in conjunction with your asso-

ciation's committee on legislation. The good work already done in this direction by existing state or sectional associations has been very much appreciated by the interests benefited.

It was my intention to suggest a codification of the laws of the several states relating to the central-station industry, for the benefit of our members and others interested, but the work has been done, in a manner, and is now in book form.

Another important question is that of municipal ownership, which, while as yet limited generally to the construction and operation by municipalities of plants for public lighting, is more than likely to result in the general attempt to engage in private or commercial lighting in aid of public lighting.

By way of self-protection, the central station should more than live up to the obligation of its franchises; should furnish public lighting at reasonable prices, and should serve the public so well that any agitation started for political or personal ends would not receive the support of a justly indignant public.

As the basis of the argument in favor of municipal ownership is largely that of a reduction in the cost of public lighting to the taxpayer, we should be prepared to answer this claim—as can be done—by the concrete results of the operations of existing municipally-operated plants.

It is to be regretted that the League of American Municipalities has not accepted the proposition, repeatedly made by the National Electric Light Association, to join in a thorough and impartial investigation of the results of the operation of existing municipal electric-lighting plants in this country. We know, but the public generally does not, that such results do not justify or support even a part of the claims made by the advocates of municipal ownership.

The amendments to the by-laws adopted at the last convention, relating to various classes of members, have resulted in a satisfactory addition to our membership. Members Class B are officers or employees of member companies, and now number 117; members Class C are instructors and teachers of engineering and related sciences, and now number 39; and members Class E are officers or employees of associate member companies, and now number 68. The total membership is now 824, as compared with 583 one year ago.

The Association of Licensed Manufacturers of Incandes-

cent Lamps has appropriated the sum of $10,000 for the purpose of effectively co-operating with the central lighting stations of the country for the increased use, and in consequence sale, of incandescent lamps.

The plan contemplates its expenditure in two ways:

First—To be helpful in stimulating central stations along advertising and new business lines.

Second—To assume the cost of preparation of an effectual and comprehensive plan of advertising and soliciting, which, in consequence, could be furnished by some central bureau or advertising agency at a very low cost.

As the plan suggested would be of great value to the central-station industry, I would recommend that a committee be appointed to work in conjunction with the Association of Licensed Manufacturers of Incandescent Lamps.

Our late president made some very pertinent suggestions as to the labors and difficulties attending the discharge of the duties of president of your association and the value and necessity of having meetings of the executive committee during the interim between conventions, to secure a continuity of the established policy of the association and to keep in close touch with the needs of our members in all sections of the country. The suggestions made I endorse. The individual policy and efforts of succeeding presidents, no matter how able they may be, can no longer do full justice to the interests of our members, widely scattered as they are. The executive committee must be the connecting link between the work of succeeding presidents. Its members should be selected, so far as possible, to represent geographically the several sections of the country, and should meet often enough to place the president in touch with the needs of their localities.

Steps should be taken to provide a place and facilities for a library to contain papers, periodicals and publications issued from time to time, relating to all subjects of interest to the central-station industry. The original data collected by the several committees and reporters appointed from time to time should be filed in the office of the association, together with all the correspondence on the part of the executive officers of the association and others relative to the important questions that fall to their lot to deal with. Each president in turn is handicapped

by finding substantially no record in detail of the work of any of his predecessors, and is therefore at a great disadvantage in attempting to deal with any important question that may overlap the term of more than one president or may have some relation to events of the past.

A committee should be appointed to consider and report on the proper method of grounding secondaries of alternating-current distributing systems so as to minimize the risk and danger to property and life.

The suggestion made by the committee for the investigation of steam turbines, that its work be continued, is endorsed.

While not strictly among the objects of the association, it would be well for our members to consider the advisability of consolidating the street-railway, gas and electric companies in any given locality, as not only would the public be better served, but the total investment would be more stable and the results equally satisfactory.

During the holding of the Louisiana Purchase Exposition, in 1904, your association, through the kindness of the Association of Edison Illuminating Companies, was granted the use of part of its space at the exposition for the accommodation of our members, and I desire to take this opportunity to thank our sister association for the courtesies extended.

At the meeting of the International Electrical Congress, held in September, 1904, at the exposition, the association was ably represented by the gentlemen selected at its Boston meeting. I desire, therefore, to thank Mr. George Ross Green, Dr. Frederic A. C. Perrine and Mr. George N. Eastman for their very able papers and for the manner in which they sustained and added to the reputation of the association.

But few of us appreciate the tremendous power of the association; the great possibilities for good or for evil that rest in the direction of its policy, and the importance of the interests involved. Our relations to the great public, our customers; to the legislative power, to which we are all subject; to the municipality, under whose franchises we operate; to the great manufacturers of apparatus and supplies; to the insurance interests, with whom we must always maintain the most intimate relations; and last, but by no means least, to our stockholders and all others pecuniarily interested in the properties we manage—these are

the great and vital questions that are now uppermost. It will be for future administrations to deal with them wisely and conservatively.

THE PRESIDENT: It has been customary to have a committee appointed to which the president's address is referred. I assume that the secretary will announce that committee later.

(The committee announced subsequently by Secretary Farrand was composed of Messrs. Louis A. Ferguson, chairman, Frank W. Frueauff, George R. Stetson, Samuel Scovil and S. T. Carnes.)

THE PRESIDENT: We will now receive the report on Progress, Mr. T. Commerford Martin, of New York, editor. Mr. Martin will also read the special report on the tantalum lamp, prepared by Dr. Louis Bell, of Boston.

MR. T. COMMERFORD MARTIN (New York city): Mr. President and gentlemen—As my report as editor of the committee on progress is in type, it seems hardly necessary to inflict upon you an exhibition of bad elocution. I should like merely to call your attention to the various heads of the paper and leave you to read it at your leisure. The statistics of the industry, as usual, are first considered, and one or two aspects of the growth of our industry in this country are briefly referred to. Emphasis is particularly laid by your committee on the cultivation of the small consumer, suggesting that perhaps a little less effort be made in the direction of crowding out the isolated plant and a little more energy be displayed in the cultivation of the small consumer.

In that connection it occurred to your committee that it would be interesting and valuable to have at this convention an exhibit of the advertising methods and material used by some of the companies in this country; also an exhibit of some of the "follow-up" methods by means of which the impression created by advertising is driven home and new patrons are secured. After consultation with our president it has been determined to associate with the report of the committee on advertising, to be presented Wednesday evening, this exhibit of advertising material and methods. I have some very handsome contributions from the New York Edison Company, through the courtesy of Mr. Brady and Mr. Williams, and a very handsome

exhibit from the Chicago Edison Company. Mr. Percy Ingalls, of the Public Service Corporation of New Jersey, has an exhibit of his own in connection with his report on advertising methods. We also have material from Baltimore, Washington, Boston, Philadelphia and Detroit. I think you will find this exhibit of advertising material extremely interesting and in no small degree instructive. I venture to believe and hope that you will find it helpful to you in prosecuting your own campaigns for new business, not only in the enemy's territory, but in virgin territory.

My paper then considers some of the leading central-station developments during the past year, and speaks particularly of such instances as Detroit, where Mr. Dow, our fellow-member, is carrying out an extremely interesting and ingenious development. As Mr. Dow is here, it will be interesting to have him extend the information given in my brief notes on this subject.

I then give consideration to the subject of old and new illuminants, which I need not inflict upon you except to refer to the fact that immediately after the presentation of this report I shall read Dr. Louis Bell's report on the tantalum lamp. I give in my paper some scientific data in regard to the development and purpose of the lamp; but Dr. Bell's paper is vastly more practical and vital, and I think you will find advantage in listening to every word of it. After treating of the illuminants, I go to the discussion of electric heating, and follow that up with a few remarks on electric power in general and its special application to refrigeration.

The following is Mr. Martin's report:

REPORT OF THE COMMITTEE ON PROGRESS

STATISTICS OF THE INDUSTRY

The central-station industry of the United States has enjoyed a full measure of prosperity since the Boston convention of the National Electric Light Association last May. The year 1904 was not distinguished for its unparalleled growth, as some prior years have been, but the finances and enterprises of the country passed from stagnation and depression in the first half to cheerfulness and activity in the last six months, and more particularly when political agitations and uncertainties ceased. In like degree there was greater advance towards the close of 1904 in the lighting and power field than was observable last May, and thus a number of important developments and extensions have been brought to fruition.

The statistics of the industry are always a necessary factor in any survey of progress, and they may therefore be appropriately presented here. The basis of comparison is necessarily the census of 1902, upon which the following figures are predicated. The rate of increase assumed being that of 10 per cent per annum, which is certainly justified by what is known, it would appear that the total investment in central-station plants proper up to the end of 1904 was $610,000,000. The earnings gross upon this sum were at the minimum $104,500,000 and the total expenses were $82,500,000. The same rate of increase would give 4200 central-station enterprises, a number which is believed to accord closely with the actual facts. The production in 1904 of various classes of apparatus and supplies consumed largely and chiefly by central stations is estimated to have reached the following amounts: Dynamos, $18,500,000; motors, including those for traction, $35,000,000; transformers, $5,000,000; switchboards, $3,000,000; storage batteries, $5,000,000; carbons, $2,-250,000; lighting fixtures, $3,750,000; arc lamps, $2,500,000; insulated wires and cables, *et cætera*, $30,000,000; conduits, interior and underground, $2,000,000; measuring instruments, $3,350,000. More precision will shortly be given to these and kindred figures by the United States manufacturing census of the present year, but the fact remains and is obvious that the central-station indus-

try is not only a splendid field of effort in itself but affords a tremendous stimulus and opportunity to almost the entire range of electrical production of apparatus.

It is customary for your committee to note incidentally the growth of electric lighting in other countries than our own, but these statistics are rarely compiled and are with difficulty obtainable. A few statistics may be cited, however. It would appear that in Great Britain and its colonies at the close of last year the sum of nearly £62,000,000 sterling, or about $300,000,000, was invested in electricity supply or central-station enterprises recorded in England, having increased to this amount from £8,000,000 in about nine years—a very healthy and encouraging rate of progress. The striking fact emerges that half of the sum represented company undertakings and half of it the investments of municipalities. An average dividend rate of 5.03 was shown on the private enterprises. The results of the municipal operations are, as usual, not easy to determine. During a recent visit to England your committee had an opportunity to make a rough-and-ready test of the conditions under municipal ownership, and is compelled to state that he found great discontent in many places. The glowing reports of municipal success that reach the United States are often without any kind of substantial basis, and at the best are grossly exaggerated. A daily reading of the London newspapers in March and April brought under observation columns upon columns of editorial and other articles as well as scores of letters, complaining of municipal extravagance, citing instances in many of which electric lighting was referred to as poorly done at high prices, and calling for a halt in the socialistic programme that is rapidly landing England in a sea of municipal debt and disaster. Mr. John Holt Schooling, in his summary of the report of the Royal Commission on local taxation, intimates that the figures are unfavorable. On municipal electricity supply plants in England involving an investment of $60,000,000 the loss in operation was shown to be 68 cents per $500 of capital, without due allowance for depreciation. If five per cent depreciation were allowed, the yearly loss per $500 of capital investment reached $23.64. Such figures are not encouraging.

The statistics for Germany are somewhat fuller, and are obtained from the compilations of the Elektrotechnische Zeitschrift

published last January. There are over 1100 central stations in Germany, and the figures herewith relate to no fewer than 1028 of them as of April 1, 1904, so that probably, in order to equalize them with American figures, a 10 per cent increase should be allowed. Only those plants are included that sell currents to consumers or supply public lighting, while isolated plants are not included. In 1904 there were fifty-one plants in Germany of a capacity of more than 2000 kilowatts. The three largest plants are three Berlin stations of 85,136, 30,000 and 25,895 kilowatts, respectively. The total capacity of the fifty-one stations of more than 2,000 kilowatts is 290,693 kilowatts, these stations being in thirty-three cities. The development of central stations and their connections in Germany in general is shown in the following table:

	1894	1900	1904
Number of stations........................	148	652	1,028
Number of 50-watt incan. lamps connected..	493,891	2,623,893	5,687,382
Number of 10-amp. arc lamps connected.....	12,357	50,070	110,856
Horse-power of motors (not including traction)	5,635	106,368	263,036

In recent years several plants have been erected which supply current to a number of cities and towns in a district; thus the Bruehl central station supplies current for lighting and power to sixty-six towns at a distance of from nine to twelve miles from the station. On the other hand, there are some small plants that supply current for power purposes to houses for the support of house industries. A typical example is the Anrath plant near Crefeld. All the motors connected to the mains are in this case between one-quarter and one-half horse-power, and are used in the silk industry. In recent years the use of power has enormously increased, as is shown in the following comparison for the Berliner Elektricitäts Werke of the kilowatts used for lighting and for power, traction motors not being included:

	Kilowatts for Lighting	Kilowatts for Power	Number of Motors
1885....................	250	....	....
1890....................	3,899	112	28
1895....................	10,752	2,252	663
1900....................	21,122	22,037	5,764
1904....................	36,195	44,448	12,933

There is only one plant in Germany that buys energy in bulk from a larger plant and sells it in retail to consumers; this is the Spandau station, which gets the current from one of the Berlin

works. Statistical data concerning the systems used are given in the following table:

	Number of Works	Kilowatts of Machines	Kilowatts of Batteries	Total Capacity in Kilowatts
Direct current with storage batteries	803	175,263	69,957	245,220
Direct current without storage batteries	40	2,346	.....	2,346
Alternating current, single-phase and two-phase	41	37,317	400	37,717
Three-phase current	63	69,054	1,532	70,586
Monocyclic system	2	1,030	152	1,182
Mixed three-phase and direct current	64	141,330	23,169	164,499
Mixed alternating and direct current	15	8,542	855	

Concerning the power used, the statistics show that 570 plants with 341,248 kilowatts use steam power, 109 plants with 14,547 kilowatts use water power, 208 plants with 60,672 kilowatts use both steam and water power, and 94 plants of 10,050 kilowatts use gas power.

At a time when the wonderful achievements of Japan in war are challenging the attention and admiration of the world it is worth while to note the great development of the arts of peace in that marvellous country as exemplified by the growth of electric lighting. This is well illustrated in the curve of current output recently published by the Nippon Denki Kiokwai—the Japanese Electrical Association—which corresponds very closely to our own organization. This curve is a sharply rising one, and the capacity of the Japanese central stations has risen from 3000 kilowatts in 1893 to over 26,000 kilowatts in 1903—a tenfold increase.

GROWTH IN AMERICA

As far as America is concerned, the best exemplification of growth is found in the study of some single enterprise, and this is well furnished by the New York Edison Company. At the annual dinner of the company last December, when some thirty members of the contract and inspection department were present, Mr. Arthur Williams said: "One's memory readily goes back to the time when all the employees of the company numbered less than half of those present this evening; when the entire territory supplied covered less than one square mile instead of more than seventeen square miles, as at present; when there were less

than 300 customers instead of something more than 34,000; when there were no arc lamps compared with about 23,000 supplied to-day, and to the time when the first horse-power in an electric motor applied to commercial service was connected as a class of our business, which has now grown to more than 90,000 horse-power in motors engaged in every industry in New York City in which mechanical power is used. But the greatest part of this extraordinary development has occurred within the last five years, in which years the growth has more than equaled the aggregate growth of the preceding seventeen years of the company's history. Our customers have grown from 16,000 to the present number of nearly 34,000; the incandescent lamps from 750,000 to 1,600,000; arc lamps from 10,000 to 23,000, and power from something less than 40,000 to something in excess of 90,000 horse-power." It was remarked that night that one of the instrumentalities of the company's advance had been its monthly Bulletin, reaching all actual and prospective customers. It has seemed to your committee that this admirable Bulletin and the excellent ones also issued by the central-station interests in such cities as Boston, Brooklyn and Baltimore, as well as by the Public Service Corporation of New Jersey for its vast net-work, are a most powerful argument in securing new custom. Other and smaller central-station companies might well adopt and imitate the same plan, either singly or by co-operative effort. The missionary work that the Denver Gas and Electric Company also performs in its campaign for business is well worth study. An interesting bulletin associated with a "follow-up" system and reinforced by newspaper advertising, postal cards and letters, as well as by the regular and more conventional canvass by agent, will accomplish wonders in adding to a station output. The average consumption of current per individual in our towns and cities is still very far below what it should be and will be, and every appeal must be made to the prospective consumer.

CULTIVATION OF SMALL CUSTOMERS

In this respect, and with due deference to the good work done by those actively employed in the field, it has seemed to your committee that enough was not being done to cultivate and create the small customer. Efforts have been made recently to direct attention to this rather neglected opportunity. The

figures of the New York Edison Company were quoted above, showing, roughly, 35,000 customers. That is a goodly number, but who believes for one moment that such a figure is the limit of possibilities on Manhattan Island? It ought soon to be 70,000 as a minimum, for if the average family be taken as five persons, that accounts for only 350,000 people out of, say, 2,000,000, and electric light and power are falling far short of the ideal and final in reaching only one-sixth of the population in a given territory. It should be interesting for the companies to compare notes along these lines and see how large a percentage of the population they are reaching respectively with their circuits. It is to be feared that the public and too many central-station companies still regard the electric light as a luxury, the electric motor as dear, and electric heat as quite out of reach. This was true once as to light and power, but is so no longer. The industrial electric motor is going in on every hand, but very largely as the basis for an isolated plant. The two principal changes that have made possible great reductions in electric-light cost to small consumers have been the lower rates for current and the perfection and use of cheaper lamps as well as of lamps of smaller value than 16 candle-power. The small consumer is, moreover, just as alive to the conveniences of electricity as the large consumer and is susceptible to the right arguments. The case can be quoted of the superintendent of a central station in a manufacturing town of moderate size who is making very successful efforts to increase the number of workingmen's homes connected to the central-station circuits. He argues that these small customers are more desirable from the lighting company's standpoint than are the large residences, for a number of reasons. The smaller houses are not so widely scattered as large residences. The regular demand and the maximum demand are not so widely different in the case of a number of small residences as in the case of one large residence, and the income of a given number of lamps connected will be larger in the case of the small residences than in the mansions. To be sure, there is more clerical labor required to keep a large number of small-meter accounts than the account of one large residence, but this is partially offset by the fact that these small accounts usually give little trouble, and there is less unreasonable kicking from the small customers than from the owner of the large residence who

has a very small bill and a very large maximum demand at times. This superintendent has adopted the plan of paying a small commission to building contractors for securing the wiring of the workingmen's cottages they are erecting. In this way very few workingmen's homes are built in that rapidly growing manufacturing city that are not wired for electric lights. By making it an object for each building contractor to push the introduction of electric light in this way the company is saved the expense of watching the business and of having solicitors call on every real estate owner who may be building in the town. Building contractors being comparatively few in number and directly in touch with the owners of the buildings they are erecting, they are in position to do easily what it would cost the company considerable money to do through special solicitors.

Probably no more promising field exists for increase of business in towns where other classes of load have been thoroughly worked up than this field of the lighting of small residences. In order that this class of electric lighting may not suffer on account of its expense to the consumer, it would be well for some one connected with any large central-station company to make it a business to see that these small consumers are equipped to use electric light economically and to the best advantage. One of the principal points to be looked out for along this line is the use of low candle-power lamps whenever and wherever such lamps will give sufficient light for the purpose, the avoidance of waste by turning off lights when not required and the use of efficient reflectors and globes that will deliver the light at points where it is needed.

In our larger cities the effort hitherto seems to have been to convert or suppress the isolated plant rather than to secure the small consumer. It is open to question whether the isolated plants have yet decreased much in total capacity, and they will certainly be with us always; but in the meantime the small customer seems worthy of attention as well. In the aggregate his consuming power is enormous, and in the final analysis all our great and permanent industries depend on him.

NEW CENTRAL-STATION WORK

During the past year of the association a number of member stations have undergone extension and improvement involving

features of interest. Last year we all had the enviable opportunity to examine, just as it went into operation, the new turbo-generator station of President Edgar in Boston, equipped with four-stage Curtis turbines, each of a rated capacity of 5000 horse-power and with all the apparatus installed on the "unit system." It has settled down smoothly to its service, adding one more typical example of American enterprise and thoroughness in engineering. It can not be said that the principle there seen of remote control for switching apparatus is fully accepted. Some designers still prefer that the operator in charge of a plant shall be where he can "see it clearly and see it whole" and keep in visual touch with it.

A more recent example of central-station work is to be found in the new plant of the Detroit Edison Company, at Delray, four miles from the business centre of the city. There our fellow-member, Mr. Alex Dow, has dealt with a rather novel proposition, and has met it in ways somewhat out of the common. At Delray, on the Detroit River, the company has secured no less than 30 acres, and the main object of so extensive a purchase of land has been to enable the corporation to go into the manufacture of salt, directly or indirectly. The region is one that has long been the home of the Michigan salt industry, and the land in question lies over a huge bed of salt. The process has been carried on by pumping brine to the surface from drilled wells, and evaporating it. In the old days, before Michigan had been recklessly devastated and well nigh stripped of its magnificent resources of timber, cheap refuse was readily available for fuel from the countless sawmills; but, with the lumber gone, sawdust and shavings of all kinds have become scarce, and the exploitation of the "salt blocks" has also suffered because of the increasing dearness of fuel. The Detroit Edison Company has had the idea of drilling brine wells on its property and using the heat from its exhaust steam in the power plant to evaporate the brine, the theory being that thus all day loads could be carried very economically because of the value of the by-product, *i. e.*, the exhaust steam. At the same time it was planned to install condensers with the steam turbines, as the capacity of the turbine is thus increased about 50 per cent; and such a large reserve capacity could be secured so cheaply in no other way. The condensing apparatus could be used at times of peak load, while the exhaust steam could be used at the salt works during light load.

It will be very interesting to see how all this comes out when put to test. It reminds one of Mr. Edison's very early proposals, to associate chemical enterprises with his first central stations in order to obtain just such conditions of day-load economy as are aimed at by the Detroit salt plan. Aside from this, the new work at Detroit has other features of interest, as it embodies radical reconstruction and harmonization of old systems in one centralized plant. These features may be thus enumerated: (1) The large new generating Delray plant with 3000-kw turbo-generators; (2) the generation and transmission of electrical energy at 4600 volts, three-phase, 60 cycles, instead of the more familiar 25 cycles usually employed for transmission to direct-current substations; (3) the use, as in Europe, of motor-generators, instead of rotary converters; (4) the use of steam engines at some substations to supply steam heat besides helping out the system; (5) a system of tie lines, which enables the engines to be run during the steam heat peak, on certain substations, to help out the electric load peak on other substations; (6) an extensive power service and the distribution of power current direct to factories by means of 4600-volt, three-phase circuits. There are various novel features here disclosed. The steam-heating business is carried on by a corporation called the Central Heating Company, and, so far as known, the Detroit Edison is the largest central-station enterprise to be associated with steam-heat supply. The adoption of current of 60 cycles and of 4600 volts is also a distinct variation, the one enabling its use for incandescent lighting, and the other sufficing for the relatively short transmission. Efforts towards universal standardization and uniformity of current supply are on the whole to be welcomed and preferred.

One of the most interesting tendencies of the past year has been that of making coal-power stations centres of distribution as well as of "consolidations." The lighting art has seen two developments of this nature, but of different character. One process now familiar has been that of organizing a holding company whose business it is to own and operate local companies in various parts of the country. Philadelphia and Boston have been more particularly the foci of such work, and some of these conglomerate enterprises have been conducted on a large scale. It is evident that such management, employing a high grade of financial, economic and technical talent, has a splendid opportunity to secure

good results, and does so; but these are often counterbalanced by the local prejudice against outside control, and by the fact that the plants thus centrally owned are scattered geographically. The other tendency that has been quite noticeably displayed during the past year is that of bringing together in one great network all the central stations in one district, constituting many of the smaller plants mere substations and concentrating the generating machinery in one or two main plants. This often includes electric railway operation, and it does look as though the future of the industry in many regions would hereafter be in the hands of what your committee would designate as "territorial" companies, in contradistinction to "local" companies. Perhaps the Public Service Corporation of New Jersey, furnishing current for light, traction and power over a large section of that commonwealth, is the best instance that could be cited of the undeniable and irresistible movement in this direction—the tendency being based on the belief that thus electric current of one type can best be generated and supplied to large masses of the population and to large areas of the country. That the thing can be overdone is obvious. Mere bigness is no criterion of economic efficiency. But it is equally clear that just now the art is looking that way for a solution of the pressing problems that confront it. In this respect England offers interesting examples. In London, where some threescore authorities, largely municipal, have powers to operate, it is proposed to establish one great company able to produce and furnish current in illimitable quantities at a minimum rate. Needless to remark, the scheme fails in many quarters to arouse enthusiasm; on the contrary, it excites mere hostility; but it appears to have powerful and cogent arguments in its favor, in regard to supplying cheap, uniform current to a vast area and a dense population. Elsewhere in England, district electric-current distribution is making distinct headway, and some of the new schemes, postulated on the use of coal almost at the pit mouth, are grandiose in character. One of them that may be cited as an example, which has already started, is that of the South Wales Electric Power Distribution Company, whose district includes such important towns as Cardiff, Swansea, and Newport, all of which have municipal plants. The present area covered is 1034 square miles, and there are four sub-districts, each with its own generating station. It is now proposed to include another area of 960 square miles.

At present the highest pressure is 3000 volts, and the frequency 60 cycles. Should the new territory be taken on, the voltage will probably be 30,000.

As a further development of central-station work along changing lines may be noted the fact that the California Gas and Electric Corporation of San Francisco are equipping one of their plants with three 4000-kw gas-engine-driven generators. The engines will be the largest of the kind in the world, and are therefore well worthy of close study when they go into operation. Each of these units is to deliver 4000 kilowatts at 13,200 volts, at 88 revolutions per minute, and with a frequency of 25 cycles. As a matter of fact, the current is to be furnished to the United Railways of San Francisco. The generators, of the Brown-Boveri type, built by the Crocker-Wheeler Company, are said to be peculiarly adapted by their large inherent damping effects not only to parallel operation, but to be driven by gas engines with a load notoriously fluctuating. They will also be capable of working as motors in starting the engines that drive them, operating the compressors until the latter are ready to supply the proper explosive mixture.

Before passing from the general subject of central-station work, reference may perhaps be made to the work done by the Columbus, O., Public Service Company in supplying hot water as part of its business. The success of central-station steam heating is probably too well established and admitted to need discussion here. But the hot-water plan may not be so familiar. The station equipment for this hot-water heating system is simple. The return water from the system enters the suctions of the circulating pumps, and is forced through the overhead heaters and thence again to the system. Provisions have been made for passing all or any portion of the water through economizers or through two of the boilers. The heaters are of Yaryan design, containing about 500 square feet heating surface each, and are practically surface condensers, except that the exhaust steam flows through the tubes, and the water to be heated surrounds the tubes, which are one-half-inch in size and about 500 in number. Six heaters are in place, and six additional are provided for. The heaters are operated ordinarily by exhaust steam, but live steam can be introduced during light loads or severe weather to three of the heaters. Each connection from the exhaust header to the

heater is equipped with an oil separator. The condensation from heaters is returned to the boilers by automatic receivers. The station piping is so arranged that the heaters can be used for surface condensers for the main engines, and the exhaust from all auxiliaries can be discharged directly to the feed-water heater or to the exhaust main. The circulating pumps can be operated on a cooling tower and through the condensers. An expansion tank six feet by 18 feet is connected to the heating system return. The 24-inch exhaust line from the engine-room basement rises through the boiler-room floor and with branches 20 inches to the feed-water heater and 20 inches up to the heaters or condensers, above which a back-pressure valve is placed. The Cochrane feed-water heater is supplied with the Sorge system of chemical treatment, and space and blank connections are provided for a duplicate heater. The circulating pumps are duplex, tandem-compound, piston-pattern, 14 inches by 20 inches by 15 inches by 18 inches, and the boiler feeders are extra heavy, single, outside centre packed, plunger pumps 12 inches by 9 inches by 18 inches. The hot-water distributing system covers the best residential territory of the eastern part of the city, and most of the mains are laid in alleys. The two-pipe system is used, with thermostatic regulation of customers' services, operated by a galvanized-iron compressed-air line run in the same trench with the heating mains and supplied by two Westinghouse compressors at the plant. The discharge and return pipes of the heating mains are laid in the same conduit, built of cypress wood. It is underlaid in clay or compact earth, with porous drain tile laid in a coarse gravel bed, for drainage. The insulating conduit is overlaid with asbestos shavings treated with crude oil.

The distributing system consists of about 6000 feet of 12-inch, 1800 feet of 8-inch, 1500 feet of 6-inch, 7000 feet of 5-inch, 14,000 feet of 4-inch, and 7500 feet of 3-inch Byers wrought-iron pipe. The system has an ultimate capacity of nearly 300,000 square feet of radiation, and has about 60,000 square feet connected at present. Expansion and contraction are provided for by flanged, packed, slip joints of bronze on 6-inch pipe and larger sizes, and U-bends are used on smaller sizes. Anchors are placed midway between the expansion joints, which are spaced about 400 feet apart. Flanged valves are placed on lateral runs, and all valves and expansion joints are placed in brick manholes.

Service taps on mains of four inches and smaller are made by means of cast-iron tees, and on larger sizes are tapped directly into pipe. The greater part of the service is 0.75-inch, 1-inch and 1.25-inch in size. The heating business of the company has had a very rapid growth, notwithstanding the competition of natural gas at 25 cents per thousand.

THE PROBLEM ABROAD

Reference has been made to the lighting situation in London, with its threescore monopolies, and to the proposal to reduce these to something less primitive and barbaric. In Paris a similar condition exists, owing to the falling in of the present franchises for the "sectors" or districts, and the opinions of a number of authorities have been invited as to the manner in which the supply of current may be simplified and unified. The answers show an adherence to the plans and policies adopted in America, and all the questions that have come up sound as familiarly in our ears as household words. It will perhaps suffice to quote one example, from which the rest may be inferred. The Siemens-Schuckert Company considers it rational to establish one or two steam-driven central stations of a total capacity of about 80,000 horse-power, with steam engines or steam turbines driving three-phase alternators of 5000 to 10,000 horse-power, the voltage being 8000 to 10,000. For the secondary distribution system two solutions are possible. The first is to transmit the 10,000-volt, three-phase currents by underground cables to numerous transformer stations, where the high-tension alternating current is transformed to low-tension alternating current for transmission on a four-wire system, the tension between the phases being 210 volts and the tension between the neutral wire and the three phases being 120 volts, the former voltage being suitable for motors, the latter for lighting. The second method is to transmit the 10,000-volt, three-phase current to a certain number of substations for conversion into direct current. The company favors the latter system, with distribution on the three-wire system. Unlike the Siemens-Schuckert Company, the Allgemeine Elektricitäts Gesellschaft considers three-phase, low-tension current distribution as the most favorable system for secondary distribution in Paris. For each central station it is proposed to install two steam turbines of 10,000 horse-power each and five of 20,000 horse-power each.

Whatever the plan is, it will be universal or "monopolistic," *i. e.*, scientific as contrasted with parochial.

OLD AND NEW ILLUMINANTS

The next stage of our report takes us to a consideration of new and old illuminants. As compared with the enclosed arc, the open arc hides its diminished head. In his very interesting article in the May *Century* by Mr. Charles F. Brush on the invention and development of the arc light, the growing supremacy of the enclosed-arc light is noted, one company alone selling 85,000 in 1903, while its effect in checking the use of carbons is also noted. For street lighting the old carbon arc in one form or another still reigns supreme, but its place is not altogether undisputed; while modifications and improvements are happily still the order of the day. As compared with gas, for street lighting, the arc has fairly established its place, and it is even now steadily invading the territory of its rival and competitor. In this respect, we may note the recent figures of Mr. Pearce, chief electrical engineer of Manchester, England. It is shown that for a degree of illumination equivalent to 1000 candle-power, lasting 4000 hours, the cost of "intensified" gas lighting, calculated on a basis of 2.16 cents per 1000 cp-hours, which includes 10 per cent depreciation, with electrical energy at 1.90 cents per unit, the cost of electric lighting works out at only $63.12. From actual measurements taken Mr. Pearce finds that the cost per mean candlefoot per hour for the arc lamps is 0.66 cent, whereas that for intensified gas lamps is 0.79 cent. These tests can in no sense be regarded as mere laboratory experiments, since they were carried out under ordinary working conditions by practical engineers, with an instrument the accuracy of which is beyond doubt. Mr. Pearce's figures for electric light are due, in large measure, to the low cost of electrical energy and to the employment of arc lamps that do not require retrimming or any other attention for many hours. At the same time, the price of gas in Manchester is also very low, and the improved system of gas lighting is claimed to be very economical as regards maintenance and labor.

The best general review on the illuminating situation is that of Wedding in his paper before the Cologne Electrical Society, part of which may fittingly be cited before this body. In the following table the first column of figures gives the efficiency

defined by Wedding as the quotient of the energy given out in the form of useful light (light of the wave lengths of the visible

	Efficiency	Calories per Candle per Hour	Cost per 1000 Candle-hours in Cents
Kerosene lamp	0.000 29	36.4	21.
Gasoline	0.000 063	16.3	22.
Welsbach incandescent gas light	0.000 18	11.0	6.8
High-pressure incandescent gas light	0.000 65	6.48	4.5
"Lucas light"	to	7.82	4.8
"Millenium light"	0.000 96	5.77	3.5
Carbon filament electric lamp	0.002 to 0.0048	2.6 to 3.99	30. to 46.
Osmium lamp	0.006 2	1.34	16.
Nernst lamp	0.008 5	1.63	19.
Electric arc lamp	0.002 98 to	0.9	11.
Flame arc	0.003 38	0.2	2.3

spectrum), divided by the total energy consumed by the lamp; it will be seen that even the best efficiencies in this table are below one per cent. The second vertical column gives the calories consumed per hour for the production of one spherical candle. The third column gives the cost per thousand candle-hours in cents, but the author emphasizes the point that these figures should be used cautiously, since many other factors decide the advisability of using a certain light. The author gave some notes on the zirconium lamp. It was stated that from one kilogram of zirconium 100,000 filaments can be made, and that the lamp will be sold at the price of 38 cents. The lamp consumes normally two watts per candle. Single-filament lamps are adopted for 37 volts, so that on 100-volt mains three such lamps are used in series. Single filaments are also made for 44 volts, so that five such lamps are used on 220-volt circuits. In lamps of 60 to 100 candles, several filaments are used in one lamp, so that a single lamp may be connected across 110-volt mains. Recent life tests have given a life of 700 to 1000 hours. Concerning arc-lamp engineering, it was remarked that at present three lamps (without series resistance) are used in series across 110-volt mains, but this is recommended only for large consumers. The author mentioned a new lamp of Tito Livio Carbone, in which inclined carbons are used side by side as in the Bremer lamp, but the carbons are not impregnated with chemicals. By a special magnetic device, the arc is blown downwards so as to form a hemisphere. The voltage is 90, and the light is quiet and steady. However, the specific energy consumption is higher than in en-

closed-arc lamps. Herr Beck has recently invented an arc lamp without regulating magnets, and the author stated that the lamp has given good results in the laboratory. He provides one of the two carbons (which are placed side by side in a sharply inclined position) with a longitudinal ridge which rests on a refractory foundation. By the heat radiated from the carbon end, the terminal of the ridge becomes a fine point, which burns away simultaneously with the carbon, and thus causes the gradual and continuous descent of the carbon.

IMPREGNATED CARBON ARC LAMPS

Arc lamps with impregnated carbons continue to command a good deal of attention, and the results are very interesting, especially in regard to the work of Blondel and Bremer, the principal experimenters in Europe in this field. Some data were furnished not long ago from Germany as to tests on such lamps. In the Blondel arc lamp, only one of the carbons is impregnated with salts for increasing the illumination; the positive carbon is the lower one for direct-current arcs; the upper arc is surrounded by a reflector. The impregnated lower carbon consists of three parts, a core and two concentric layers around it. The outside layer is pure carbon; the middle layer, which is the thickest one, is a mixture of carbon and salts for increasing the illumination (salts of calcium, magnesium, *et cætera*), while the central core has the same composition but is less compressed. The object is that the arc should remain always in the centre of the carbon and the carbon should burn off uniformly. The thickness of the carbon varies with the size of the lamps. For 5-ampere lamps the thickness is about 1.3 centimetres, and the length of the carbon decreases per hour about 1.3 centimetres. The upper carbon, which with direct current is the negative one, is mostly made of pure carbon and only very slightly impregnated. The vapors from the salts in the lower carbon rise into the arc and are heated to white heat, and are condensed on the reflector at the top of the lamp. The reflector consists of a central circular reflecting disc of insulating material and an external ring of metal. Lamps were first made for a current of five and three amperes, but at present there are lamps that consume only one ampere. The length of the arc is between 1.2 and 1.9 centimetres, and increases with the voltage. The normal voltage is 50. The data follow:

	Volts	Amperes	Watts	Hemispheric Illumination in Candles	Watts per Candle
The lower carbon a positive Blondel carbon of 9 mm. diameter, the upper a Siemens carbon A of 7 mm. diameter..............	57.4	2.99	171.5	1339	0.128
The same as before, but diameters of 11 and 7 mm. respectively........................	51.6	5.12	264.2	2210	0.109
The upper carbon a positive Siemens A carbon with core of 9 mm., the lower a negative Siemens carbon of 7 mm. diameter........	53.1	2.9	154.2	207	0.746
The same as before, but diameters of 11 and 9 mm. respectively........................	52 4	4.94	259.9	404	0.644
Bremer lamp...............................	....	28.6	....	....	0.100
Bremer lamp...............................	....	12.3	....	....	0.126

According to tests the Blondel lamp consumes only nine per cent more power per candle than the Bremer lamp, but this difference is thought to be of less importance since 0.1 watt per candle is obtained with the Bremer lamp only for such a high current as 20 amperes, while the Blondel lamp gives about the same result for about five amperes. The 3-ampere lamp is said to be about as economical as the 12-ampere Bremer lamp—but meantime the Bremer lamp is that which has become best known in the practical art.

MERCURY-VAPOR ARC

The mercury-vapor arc continues to make a field of utility for itself and to demonstrate economies of a striking character. It might perhaps be characterized as the "yellow peril," before which the other illuminants crumble away as do the Russian legions, but which has also its metes and bounds. A notable example of its useful quality is afforded in its adoption by the *New York Times,* whose tower, if not quite so beautiful as that of Giotto in Florence, dominates not less the landscape, and at night glows with a radiance that puts shadows on the moonlight. In both the aerial composing room and the subterranean press room, Cooper-Hewitt lamps are used, and it is worth noting incidentally that all the current for the huge building is supplied from the New York Edison mains. The unusual color of the light in the composing room at the top of the building catches the eye from any quarter of the city. There are 12 such lamps in that department, and

for the make-up tables they are considered very satisfactory by those who have worked under them, giving a cool, soft light, not unlike that of daylight. With regard to the typesetting machinery, *et cætera*, as the light casts no shadow, the type can be seen from any position. New type can also be easily read, as it has a dull appearance and casts no reflection. There are also four tubes in the mailing department. The presses are no less than 55 feet below the street surface, and the equipment is such that 144,000 sixteen-page papers can now be turned out in an hour, while an ultimate capacity of 432,000 can be provided. In the press and stereotype rooms 26 Cooper-Hewitt lamps are installed, lighting four double, quadruple, octuple presses and two autoplate machines. These tubes take the places of no less than 132 incandescent lamps and 14 arcs, consuming also but one-third of the current. They light the four presses thoroughly, as well as the area of 17,000 square feet of floor space, with a ceiling 21 feet high. Your committee has been interested to note in studying this equipment how the disadvantages of wiring around presses are obviated, as they are thoroughly well lighted by reflection. These and other lamps, 42 in all, are operated two in multiple at 118 volts, off the Edison mains. Each pair takes 3.5 amperes. Reference has been made to the economy effected in current. The original estimate for current with arcs and incandescents was 15 kilowatts. The Cooper-Hewitt outfit takes 5.46 kilowatts. Another point as to economy occurs in regard to the installation, the expense for which was greatly reduced. Had incandescents been used it would have necessitated boring about 1600 holes in the press frames. The tubes used taking 3.5 amperes per pair, have for 109-125-volt circuits a light-giving length of 20.75 inches and a total tube length over all of 27.25 inches. The diameter of the tube is one inch, and the length of the suspension bar varies from three inches to four feet. With only a 3-inch suspension bar, the lower end of the lamp is 15 inches from the ceiling.

OTHER ILLUMINANTS

The attention of your convention in Boston last year was directed to the magnetite lamp, in regard to which technical details were presented at that time. Since then a number of central stations have closed contracts with their respective cities on the basis of magnetite arc lamps for public lighting. Our own

president, Mr. Davis, has been one of the leaders in this direction with an equipment of 300 lights operating since last February. Other plants that might be mentioned are Marysville, Ohio, with a capacity of 70 lights, operating since last summer, and Harrisburg, Pa., with not less than 800 in service since last March. At St. Joseph, Mo., an equipment of 500 lights is now being installed. Your committee suggests that it would be very interesting to hear from some of the members representing these companies, as to the actual results obtained with this promising and apparently economical innovation.

The Nernst lamp, since our last convention, appears to have made considerable progress and headway, and, to quote the language of Mr. James Williamson, superintendent of the Pennsylvania Light and Power Company, of Allegheny, Pa., "as a weapon in the hands of a central-station manager fighting gas competition, the Nernst lamp is most effective." This manager states that he is replacing his arc lamps with multiple-glower Nernsts as rapidly as possible. Somewhat similar testimony is borne by Mr. G. S. Davis, of the Albion (N. Y.) Electric Light and Power Company. Mr. W. A. Donkin, general contracting agent of the Allegheny City Lighting Company, of Pittsburg, reported at the end of April a connected load of Nernst lamps equivalent to 600 kilowatts. The parent company exploiting this illuminant reports that up to January 1 it had 173 central-station lighting companies under contract, and that since then it has closed contracts with 54 other companies. Such figures indicate that the Nernst lamp has already established a place for itself in the great field of electric illumination, and is entering upon a career of great usefulness in the art.

In the field of industrial vacuum-tube lighting, Mr. D. MacF. Moore stands prominent for his persistence during many years, and for the results which he now is achieving. Attention was directed in the last report of your committee to the work done by this inventor with continuous tubes several feet and yards in length, as distinguished from tubes of three or four feet in length. Several equipments of Moore tubes have been installed, the results of which appear to be quite satisfactory. One of these is operated on the 240-volt mains of the Public Service Corporation of New Jersey in a hardware store in Newark. The continuous tube in this instance is not less than 155 feet long. The

New York *World* uptown office has a tube 154 feet long operating directly from the 60-cycle street mains of the United Electric Company. Several other installations could be cited where the tubes are of great length and where the results in illumination seem to be very satisfactory to all concerned. Such tubes would appear to have considerable life, from the fact that in one case where the plant has been in daily commercial operation for over a year for about 2500 hours, the watts per candle-power are reported to be identically the same as they were when the plant was started. The basis of operation of the Moore system at the present time appears to consist in applying to the external caps of the tubes an alternating current of high frequency, and this at first was at least eight times higher than the ordinary 60-cycle current found commonly used. This has been obtained by driving a special high-frequency dynamo by a 240-volt direct-current motor, but as stated the ordinary 60-cycle current appears now to be practically available. It is stated that the non-metallic gas used as the conductor in these tubes has enduring qualities beyond what could be hoped, giving the tube an almost unlimited life, enabling it also in the latest development to use the standard 60-cycle street mains alternating current. Criticism is heard, however, as to the apparently high consumption of current, as compared with other vacuum-tube lamps.

ELECTRIC HEATING

It can not be said that electric heating during the past year has been marked by any very extraordinary development, but there have been extensive improvements, and many refinements have been introduced, as well as modifications of existing appliances. The best sign of the times has been the willingness of central-station companies to introduce electric heaters and cooking paraphernalia to the attention of their customers, and in many parts of the country practical demonstrations have been in order, with the result of arousing considerable interest on the part of the public. Once or twice lately your committee has witnessed such exhibitions and has had an opportunity to study the demeanor of the public. Many persons have come in and inquired as to the price of the apparatus, the amount of current consumed, and its general applicability, but in other cases the ignorance displayed has been at once dense and stupendous. There is evidently here a great field for missionary effort equalling that

which was expended upon electric lighting in its early days. In view of the radical reductions in the price of current which appear to impend in various quarters, electric heating is entering upon a new stage of practical development, and it is earnestly recommended that the central-station companies give the manufacturers of such appliances a most liberal opportunity for reaching the public and for adding to the consumption capacity of the circuits. In this respect the brilliant and encouraging example of the gas companies in dealing with the gas stove may well be imitated.

TANTALUM INCANDESCENT LAMP

When we turn to the field of electric incandescent lighting, a wide range of novelty and originality presents itself, and some people are inclined to think that the twenty-fifth celebration of the anniversary of the incandescent lamp last year was also its swan song. Time alone—or American restlessness and ingenuity—can prove this to be true. It may be imaginary. First of all, we have looming up, not merely on the horizon, but literally if not grammatically "in our midst," the tantalum lamp. This takes us back at once to the beginnings of the incandescent lighting art and to the attempts made to employ metallic filaments. The new lamp we owe to the splendid enterprise and persistence of Siemens and Halske, of Berlin. With the fundamental principle as a starting point, that the visible part of the radiation from an incandescent lamp filament increases progressively with the temperature of the filament, Messrs. Siemens and Halske several years ago began elaborate laboratory experiments to discover a material for filaments that would withstand a much higher temperature than the incandescent lamp filament can economically endure. Dr. W. von Bolton was placed in charge of this work, and took up in turn for investigation a number of metals, the melting points of which are known to be considerably above 2000 degrees Cent. It was found that vanadium, as obtained from the electrolytic composition of vanadic acid, had a melting point too low for the purpose in view. Niobium and tantalum, of the same group, were then taken up, and while the former was found to have a melting point considerably above that of vanadium, it was yet too low; moreover, filaments made of this material had a strong tendency to disintegrate when heated by the electric current. In the experiments with tantalum, potassium tantalo-fluoride was reduced, and

the finely divided tantalum obtained became fairly coherent on rolling, enabling metallic filaments to be obtained. Tantalum oxide mixed with paraffin was made into the form of filaments and reduced to a metallic state. In these experiments there was for the first time observed a minute globule of molten tantalum, which was of sufficient toughness to permit hammering and drawing into wire. Following up this observation, tantalum powder was melted in a vacuum, and then it was found that the highly heated metal parted with the gases it contained. In this manner the first filaments of pure tantalum metal were produced, which, however, were quite small. When they had been used in lamps with promise of good results, an attempt was made to devise a definite process of purification. Potassium tantalo-fluoride reduced to metallic powder contains a small proportion of oxide and of hydrogen, absorbed during the reduction. When the powder was melted in a vacuum the oxide and absorbed gas disappeared, and a reguline metal remained, and on carefully remelting no appreciable impurities could be detected in it.

The chemical properties of this pure tantalum are very remarkable. When cold the material resists chemical agents strongly; it is not attacked by boiling hydrochloric acid, aqua regia, nitric acid or sulphuric acid, and it is also indifferent to alkaline solutions; it is attacked solely by hydrofluoric acid. Heated in the air, it assumes a yellow tint at about 400 degrees Cent., like steel, and also like steel the tint changes to dark blue when the tantalum is exposed for some time to 500 degrees Cent., or for a shorter time to 600 degrees Cent. Thin wires of it burn, when ignited, with low intensity and without any noticeable flame. It greedily absorbs hydrogen as well as nitrogen, even at a low red heat, forming with them combinations of a metallic appearance, but rather brittle. It combines with carbon very easily, forming several carbides which, as far as they are at present known, are all of metallic appearance, but very hard and brittle. When in the form of powder, still containing, as previously stated, oxide and hydrogen, the specific gravity is about 14; when purified by fusion and drawn into wire, it has a specific gravity of 16.8. It is somewhat darker than platinum and has a hardness about that of mild steel, but shows greater tensile strength than steel does. It is malleable, although the effect of hammering is relatively small, so that the operation must be rather

long and severe to extend the metal into a sheet. It can be rolled as well as drawn into very fine wire. Its tensile strength as a wire is remarkably high, and amounts to 133,000 pounds per square inch, while the corresponding figure for good steel is 100,000 to

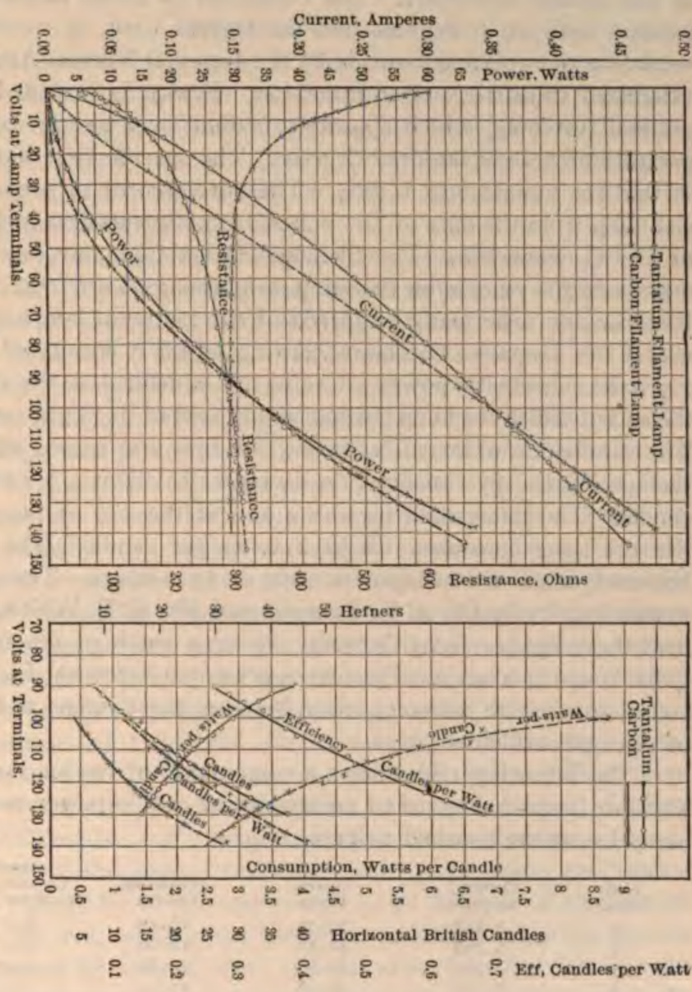


FIG. 1—ELECTRICAL BEHAVIOR OF CARBON AND TANTALUM FILAMENT INCANDESCENT LAMPS (FROSTED)

FIG. 2—LUMINOUS BEHAVIOR OF TANTALUM AND CARBON FILAMENT LAMPS

112,000, according to Kohlrausch. The electrical resistance of the material at indoor temperature is 0.165 ohm for a length of one metre and a section of one square millimetre (specific conductivity as compared with mercury, 6.06); the temperature coefficient is

positive and has a value of 0.30 between 0 and 100 degrees Cent., at the temperature assumed by the incandescent filament in the lamp under a load of 1.5 watts per candle-power, the resistance rises to 0.830 ohm for a length of one metre and a section of one square millimetre. The coefficient of linear thermal expansion between 0 degrees and 60 degrees Cent. is 0.0000079, according to experiments made by the Imperial Normal-Aichungs (standard measurement) commission. Fusion is preceded by a gradual softening, which appears to extend over a range of temperature of several hundred degrees. The specific heat is 0.0365, so that the atomic heat is 6.64. The development of a commercial lamp from the data of Dr. Bolton's experiments was in charge of Dr. O. Feuerlein. The Siemens-Halske Company has taken out about 200 patents on the lamp, comprising about 1000 claims. Experiments with many hundreds of the tantalum lamps gave a useful life of 400 to 600 hours, during which it consumed about 1.5 watts per candle-power. Useful life is defined as the time at the end of which the lamp has lost 20 per cent of its "light energy." The candle-power increases during the first 100 hours, whereby the specific energy consumption decreases to about 1.3 watts per candle. The latter then increases, and at the end of the useful life the lamp consumes 1.8 to 2 watts per candle. The lamp, however, continues to burn for 1000 or 1500 hours. Tests made in this country by Dr. A. E. Kennelly and Mr. S. E. Whiting confirm these figures from Germany, using a batch of ten frosted-globe lamps as a basis. The curves presented herewith, Figures 1 and 2, summarize the comparison between these lamps and those of the carbon-filament type.

The following table shows a comparison of the ten tantalum filament lamps in regard to uniformity of candle-power and consumption at the nominal voltage, 110.

Lamp Number	Current, Amperes	Power, Watts	Horizontal Candles	Specific Consumption, Watts per Candle
1	0.358	39.35	18.45	2.13
2	0.369	40.56	18.60	2.17
3	0.365	40.20	19.50	2.06
4	0.373	40.98	19.20	2.13
5	0.369	40.56	20.60	1.97
6	0.360	39.65	18.96	2.09
7	0.366	40.30	18.80	2.14
8	0.367	40.40	19.90	2.03
9	0.360	39.55	18.65	2.12
10	0.367	40.32	19.05	2.12
Mean	0.3664	40.19	19.20	2.10

More details might be given on the subject, but it is understood that further tests and the lamp itself will be brought before the association, relieving your committee of responsibility in the matter.

THE OSMIUM LAMP

So much for tantalum. "There are others." One of these is the osmium lamp, which has been heard of before. Some new data were brought recently to the notice of the German Elektrotechnischer Verein by Herr Blau. As the lamp is not well known in America, a few details may be cited. The present method of making the filaments is as follows:

The crude material is very finely divided osmium, which is mixed with organic binding materials so as to form a thick, tough paste, which is pressed under very high pressure through an aperture. A thread is thereby obtained which is formed into loops. The threads are then dried, and are heated in the absence of air in order to carbonize the binding material, and then subjected to the most important process, which is called formation. The threads, which now consist of porous rough osmium with a high content of carbon, are heated for a long time by means of an electric current gradually to a higher and higher temperature up to white heat in an atmosphere which contains very much steam and smaller or larger quantities of reducing gases. The filament thus becomes pure porous osmium of a far greater density than the former rough thread. During the use of the lamp the osmium surface becomes gradually more and more smooth; this accounts for an increase of the light given out by a lamp during the first few hours. The filaments of these lamps, which consume 1.5 watts per candle-power, have a diameter of about 0.087 millimetre, and a length of about 280 millimetres. On account of the increase of resistance with temperature, an increase of the voltage by 10 per cent results in an increase of the current by 6.5 per cent, while in the carbon incandescent lamp the current is increased by 12 per cent. At the same time the light in the osmium lamp is increased by somewhat over 40 per cent, while the light from a carbon incandescent lamp is increased by 80 per cent. Variations of voltage, therefore, have a much smaller influence on the light of the osmium lamp than on that of the carbon incandescent lamp. The useful life of the osmium lamp—that is,

the time in which the candle-power has decreased by 20 per cent of the original value—is about 2000 hours. The real life is very long. A large number of lamps have been burned for more than 5000 hours. In some plants in which lamps were installed in October, 1902, and used on an average from 800 to 1000 hours per year, only ten per cent of the lamps have since been exchanged. The osmium lamp is somewhat more fragile than the carbon incandescent lamp if exposed to hard knocks. The statistics on the transport of osmium lamps show that about 1.5 per cent were broken. The vibrations of railroad cars, however, have no effect on the lamp, which has proven very satisfactory for car lighting. The lamp is of excellent service when supplied from storage batteries, especially as a safety lamp for miners; for this purpose a 2-volt lamp is used. The former difficulties in making a 110-volt lamp of long life have now been overcome.

THE CADMIUM LAMP

Another candidate for favor is the cadmium, or cadmium amalgam lamp, which is an improvement on one made some seven years ago by Gumlich, who constructed a vacuum lamp containing cadmium amalgam instead of mercury. The lamp offered the advantage of adding the highly luminous cadmium lines to the spectrum of the mercury. But it failed, owing to its short life, breaking after a few experiments, whereas a good mercury lamp may last for years. Since Heraeus has succeeded in constructing mercury lamps of quartz, it suggested itself to try this material for the construction of amalgam lamps. This attempt has been successful. The amalgam used by the authors contains 14 parts of cadmium to 100 of mercury. At ordinary temperatures it is a soft mass, which on slightly heating becomes as fluid as mercury and is easily worked with. The oxidation of the cadmium is so slight as to be innocuous. The lamp may be lighted by shaking, but a better method is by using a lighting device, as in the Hewitt mercury lamps. A current flowing through a parallel inductance at 110 volts pressure is suddenly interrupted. It thus generates a high potential, which suffices to bridge the gap between the amalgam electrodes. After that the lamp continues to burn steadily with one or two amperes. It is, however, necessary to heat the lamp externally with a Bunsen burner before starting or restarting it. After some use, it is

necessary to keep the lamp steadily heated up in that way to make it burn continuously. The lamp may be brought back to its original condition by renewing the exhaustion

ELECTRIC POWER FOR REFRIGERATION

The past year has witnessed a notable extension of the use of electric current for power purposes, and the electric drive is now a familiar feature of very nearly every industry taking current from central-station mains. There are, however, many fields that fortunately still remain to be exploited, and the central-station manager is keen to detect these wherever they may exist. Mr. J. C. Chamberlain, a well-known electrical engineer, has recently drawn attention to the large field found in connection with refrigeration or cold storage, as power required in small units is a most desirable addition to the load on lighting mains.

As Mr. Chamberlain has pointed out, a refrigerating power load is essentially a small load. It is always a long load in all the hot months. The hours of daily operation follow the weather conditions closely from the summer solstice through to the winter months. It is also a day load at any season of the year and is essentially continuous, so that it can be readily determined in extent. When used in meat markets, hotels, restaurants, and food stores, this power load or demand comes on at a time in the early morning when other requirements for electric current are usually quite small. On the other hand the refrigerator load becomes less at the time of day when the electric lighting increases, for then the refrigerators are usually closed for the day and the demand for them is negligible. This refrigerator load may thus also be eliminated from the peak-load of a station, as by an automatic clock mechanism, under the control of the electric-light inspector, just as the electric meters or other auxiliaries may be. No harm is done to the refrigerator work, for while the motor driving the refrigerator machine may be stopped for an hour or two the rise in temperature in any thoroughly cooled refrigerator compartment will be but a few insignificant degrees.

In introducing apparatus falling within these conditions and requirements, Mr. Chamberlain has made an interesting presentation of the work involved and the results that apparently may be obtained: Wherever electric current can be furnished for power purposes at a rate less than five cents per kw-hour, this automatic

refrigeration effects a large saving over the cost of ice, even if the manifest advantages of cleanliness and convenience of operation be not considered; and, as an example, the following figures may be interesting in showing the cost of refrigeration by electric power as compared with the cost of ice. Take the case of a five-hp plant which in twenty-four hours will produce refrigeration equivalent to the melting of 5200 pounds of ice in the same time. Ice in a well-insulated refrigerating space of 10,000 cubic feet can maintain a minimum temperature of 45 to 48 degrees in hot weather, and will cool about 8000 pounds of food supplies during the twenty-four hours. This service requiring 5200 pounds of ice per day, or 78 tons per month, at $3.00 a ton, will cost for each hot month about $234.

Equivalent automatic mechanical refrigeration in the same space and under like conditions will produce the same temperature of 45 to 48 degrees, or will produce the usually desired cold-storage temperature of 36 degrees in a smaller space of about 7500 cubic feet. This work will require about 3.7 kilowatts, or 2668 kw-hours per month (if operated continuously), and at four cents per kw-hour will cost (including the necessary cooling water, $11) for each hot month about $118.

In other words, if the electric current at four cents per kw-hour, with cooling water, used during a hot July or August, amounted to $118 for the month, the annual cost of power will probably not exceed six times this amount, or $708. In the case of ice, using 5200 pounds per day, at a cost of $234 in a hot month, the annual consumption would be about $1404. This would show a saving of nearly $700 per year, and in less than three years the saving would be sufficient to pay for an entire five-hp plant, for such a plant installed in operation under favorable conditions will probably not cost more than $1700 to $1800.

In this comparison the refrigerating temperature of 36 degrees has been mentioned because most food supplies are best preserved in cold storage at about this temperature, but if a lower or colder temperature be required either the cubic foot space to be cooled or the refrigeration duty must be reduced, or a larger plant will be necessary. So also has an outside temperature of 90 degrees been assumed in calculating the refrigerating work necessary for the cubic foot spaces mentioned; but less severe weather conditions will allow either an increase of cold storage duty or decrease in running hours of machine per day.

Mr. Martin: I want to say, in connection with Dr. Bell's report, that I have with me, through the courtesy of Mr. Edward D. Adams, of New York, twelve of the tantalum lamps. I venture to say that to many of you this metallic-filament lamp is a novelty. Some of the gentlemen present have had this lamp under test and can therefore corroborate or contradict Dr. Bell's figures from their own data.

Mr. Martin then read the report of Dr. Bell, as follows:

THE TANTALUM INCANDESCENT LAMP

The writer was lucky enough to receive through the courtesy of Mr. E. D. Adams ten 25-Hefner, 110-volt tantalum lamps. These were, with the kind assistance of Professor Puffer, put through various tests, and in particular two of them were given a decay test with the rather startling results recently published in a joint paper. The upshot of the matter was that these two lamps, selected as being about the average of the lot in performance, gave a life of some 850 hours before falling below 80 per cent of their initial candle-power, and were both burning at 16.6 candle-power at the end of 1190 hours, although one of them had at some unknown time in the previous three days' run broken a filament close to one of the spider arms and had automatically mended itself by the fall of the loose end across the other side of the same loop, where it welded itself firmly into place and went on burning.

These two lamps ran 800 hours of their life at a mean horizontal candle-power of 20 and at about 2.05 watts per candle, thus giving 16,000 candle-hours of useful life at this extremely high efficiency. On a rating of two watts per candle average the lamps were good for 600 hours, giving over 12,000 candle-hours. On a rating of 1000 hours they gave nearly 19,000 candle-hours at a mean energy consumption of, say, 2.15 watts per mean horizontal candle. The circuit on which the run was made was on the average fully up to the rated 110 volts, although the pressure varied somewhat irregularly, perhaps a couple of volts on each side of this figure.

The light of the tantalum lamp is, as might be expected from its high efficiency, rather whiter than that of an ordinary incandescent, being as white as the Nernst lamp or the acetylene flame. Its distribution of light is in the present form of filament rather less uniform than that of the common incandescent, being relatively more powerful in a horizontal zone and less powerful for points near the axis. The ratio of mean spherical to mean horizontal candle-power, as found in Professor Kennelly's

investigation of the frosted lamps, proved to be 0.73, and the writer's figure from the clear lamps was substantially the same. The distribution, however, could very easily be improved, so that the spherical reduction factor would not differ materially from the usual figures and the light at the top could be correspondingly increased.

Since the tantalum filament has a low initial resistance (between 55 and 60 ohms) it jumps into incandescence with startling rapidity as compared with a carbon filament, but because of its positive temperature coefficient it seems to be decidedly less sensitive to changes of voltage in its working condition. This is a useful property in certain respects. The fact, however, that the initial resistance of the tantalum is so low and its thermal inertia so small owing to its small mass and low specific heat, means rather violent heating up, which is probably the cause of some doubts that have been expressed as to the endurance of these lamps upon alternating circuits. It is not difficult to imagine pretty severe strains upon the filament if it had time to cool down much between impulses. If such cooling could take place, for instance, on an ordinary alternating circuit, the results might be serious.

Some stroboscopic tests were therefore made at the last moment to determine whether at, say, 25 there was a specially violent fluctuation of light from the tantalum lamp; in other words, to find out whether on a 25 ~ current the filament had time to cool down materially. The result showed that the light fluctuation at this frequency was somewhat but not much more pronounced than in a carbon filament. The tantalum lamp behaved, in fact, about like a 10-cp carbon-filament lamp. Even a 75-cp carbon-filament lamp, however, shows perceptible variation under this test. At 60 ~ the fluctuation, while still perceptible, was trivial both in the tantalum and the carbon lamps. It hardly seems probable that at 60 ~ the life of the tantalum would be enough impaired to cause serious trouble, but the writer now has some lamps on alternating-current tests and proposes to pursue the inquiry.

The tantalum filament seems to stretch and sag at first as if undergoing annealing and losing the set produced by drawing. Then it shows local bright spots, which grow lumpy, as if the material tended to flow a little from the heat, and with the

increasing lumpiness the filament draws up tight. At this stage it is rather fragile and would probably break easily from vibration or shock. It seems likely that the final break comes just where one of the lumps has reduced the cross-section of the wire beside it. The break in the lamp during test, already referred to, showed considerable attenuation of the loose end.

The lamps as tested showed the following characteristics:

Lamp	Watts	Candle-Power	Watts per Candle
Clear globes	41.58	21.42	1.94
	38.61	20.90	1.84
	41.58	24.93	1.66
	41.58	21.55	1.93
	41.91	21.81	1.92
	41.91	22.59	1.85
Frosted globes	40.36	19.79	2.03
	40.04	18.54	2.15
	40.04	18.74	2.13
	40.48	19.27	2.09

The mean result from the clear globes was 22.2 candle-power at 1.85 watts per candle-power, that from the frosted globes 19.08 candle-power at 2.1 watts per candle-power.

It is interesting to note that the clear lamp gives just about one candle-power per inch of incandescent filament, which implies an intrinsic brilliancy of somewhere about 500 candle-power per square inch of filament—a figure much higher than in the ordinary incandescent.

As illuminants the lamps are certainly very excellent, but their introduction raises some most interesting questions for the central-station operator.

Putting aside all the petty questions that will be raised about the new lamps for commercial reasons, the broad fact remains that we are here dealing with a *bona fide* two-watt lamp having a life fairly comparable with the carbon-filament lamps now customarily in use. Moreover, it is a competitor of these, socket by socket, and not a substitute with particular requirements as in the case of the Nernst lamp or the very small arcs. There is some doubt as to the life of the tantalum lamp when exposed to unusual vibration, which may perhaps bar it in some special locations, but for the everyday work of the central station there is good reason to believe it generally applicable.

Its price can hardly be said to be fixed in this country, but

abroad, in Berlin, it is about \$1.00 (M. 4), which will give at least a fair line on its commercial results. On this basis and with current at 10 cents per kilowatt-hour one finds, taking the new lamp on its 600-hour rating, that the cost of its 12,000 candle-hours, including the lamp, amounts to \$3.40. The same number of candle-hours from a lamp giving a mean efficiency of 3.25 watts per candle would cost \$3.90, exclusive of lamps; that is, the consumer could afford to pay \$1.00 for the new lamp better than to take the old ones free. With current as low as five cents per kilowatt-hour, the user of tantalum lamps could only afford to pay 75 cents per lamp as against getting carbon lamps free. That means that a sliding scale of discounts for lamps according to quantity could be made to catch the consumer at all prices ordinarily charged for current by central stations. Does this mean that the carbon lamp will shortly be down and out? Probably not, for there is no spur like competition to start up improvements, and there are some signs that carbon lamps may be improved enough in efficiency to make things interesting, at least with current at the prices charged to very large consumers. This, however, remains to be seen, and the thing which the central-station man has to meet is the immediate probability of consumers putting upon their circuits lamps taking less than two-thirds the energy per candle-power of the best lamps now in use and thereby cutting down their meter bills enormously. Now, broadly, what shall be the attitude of the central-station man toward this income-scalping innovation? There are some managers who may be inclined to put up a fight to discourage the user, either by raising pettifogging objections or by trying to discriminate against two-watt lamps by readjusting discounts in various ingenious ways. The writer is very strongly of the opinion that such a policy is wrong and will certainly lead to ultimate disaster in the form of municipal restrictions or regulation of rates by law. In the long run, opposition to improvements does not pay. If, on the other hand, the central-station man hangs quietly on and gives the consumer the glad hand, the change will work to his ultimate benefit. In the first place, the tantalum lamps now made are of 22 candle-power, instead of 16, and the filament will hardly bear much reduction in cross-section. The tendency therefore will be to use these slightly more powerful lamps,

taking, say, 42 watts instead of a trifle over 50 watts in the 16-cp carbon lamps. The actual loss in energy sold is likely therefore to be for the present quite a little less than the difference of efficiency would indicate.

Besides this, the attraction of cheaper light will certainly bring into line new consumers, so that the net result will probably be an actual increase in sales of current, quite a little of it being along the smaller consumers who pay the higher rates. Such a change means, upon the whole, more lights connected per unit of capacity in transformers or feeders, and hence a slightly better utilization of material and improved load. In the case of stations with underground service, the change to two-watt lamps ought to bring with it increased earnings per unit of cable capacity. The fact is that improvements in the efficiency of utilization of electric energy help the business, and it is both fruitless and inadvisable to oppose them from any short-sighted notion of small temporary savings.

I have here said nothing regarding the inevitable competition between present lamps and the newcomer. In the first place the merits of the final issue remain to be determined, and in the second place competition in lamps is, on the whole, a good thing for the user of them, however it turns out. So far as the central station is concerned, it is a case of "dog eat dog."

The really important thing is that from now on the station manager will have to deal directly with the two-watt-lamp proposition, for there is no disguising the fact that it is here, and in a form that is quite unexpected. The appearance of tantalum lamps in quantity may be a little delayed in this country, but delay will improve them, as in the case of every new product, and will serve to assure a better understanding of their truly remarkable properties and of their possible limitations. The unexpected has certainly happened, for most engineers had long ago abandoned the idea of a lamp with a metallic filament. Only the discovery of a metal virtually new, and possessed of most sensational qualities, could have brought about the present striking result.

DISCUSSION

The President: This paper is now open for discussion. Mr. Cravath, you have had some experience with this lamp?

Mr. James R. Cravath (Chicago): Not sufficient to enable me to discuss the lamp.

The President: We should like to hear from Mr. Arthur Williams.

Mr. Arthur Williams (New York): Mr. President, the tantalum lamp has been before us for too limited a time to judge of it from commercial experience. We have had a number on test, and these tests—and reports of others tests, including the report we have just heard through Mr. Martin—promise a very marked improvement in the future economy of incandescent lighting. I am of the opinion that it makes very little difference to the consumer whether he buys part of his light in current and part in lamps, or all in current, and that with this lamp remaining at the present price—$1.00 in Germany and perhaps $1.50 or $2.00 here—it will not be an immediate and serious competitor with our present form of incandescent lamp. As an illuminant, it is certainly very interesting, and promises well for the future.

Mr. John F. Gilchrist (Chicago): The bringing out of this lamp raises a question that has been in the minds of central-station men for some little time, and that is the question of selling electricity for illuminating purposes, particularly incandescent lighting, on the lamp-hour basis instead of the kilowatt-hour basis. It can be readily seen that should it seem wise to push this lamp hard, the first thing that the central-station man is liable to consider if he is selling current on the kilowatt-hour basis is that it will cut down his income; consequently, while he may agree with Mr. Martin that it is unwise to hold back anything that has merit, he may want to hold it back until he can build his business to meet it and not impair his income too much. In the legislative action that seems to have taken the form of a wave throughout the country, the talk seems to be entirely along the lines of the kilowatt-hour, and it has occurred to me that it might be a wise proposition for this association and the electric-light men to try to guide that legislation along the lines of stipulating a charge on a lamp-hour basis, so that any new lamp of this type can be put out by the central-station men with advantage to themselves, which they can give to their customers in such degree as they see fit.

Mr. A. C. Dunham (Hartford, Conn.): I have experimented with the tantalum lamps, and I find that the tests given in this paper are practically correct. They burn a long time

after the filament breaks. It has occurred to me that the history of the osmium lamp is a curious history. Enough osmium could not be found to make a large quantity of the lamps, and the system was adopted of putting the lamps on central stations and charging 20 cents a month rent. The central station is paid for the power consumed by the osmium lamp at the same rate as for the carbon lamp. The lamp is returned and made over into a new lamp, and the osmium lamp goes on indefinitely. There is small wastage. I think we must find some way in which to get over the sudden drop—if it is sudden—on the tantalum lamp.

Mr. Dudley Farrand (Newark, N. J.): We have had two of the tantalum lamps. The first showed an efficiency of 1.99, which is better than that mentioned by Dr. Bell. That lamp, however, lasted only some twenty-odd hours—a little over a day. The second lamp is still burning and shows an efficiency of 1.68. I do not know how long that will burn. The commercial efficiency is a matter that will have to be determined; the theoretical efficiency amounts to very little.

Mr. Gilchrist touched on the question of cutting down the revenue of the central station by using a high-efficiency lamp. My own opinion on that subject is that it is not going to work against the company's interest a bit. Every time you double the efficiency in your lamp you double the plant's capacity; and while higher efficiency may tend to increase the distribution expense, the net result will all be in favor of the high-efficiency lamp. I am heartily in favor of it, and only wish we could get the lamps in sufficient quantity to supply our business to-day. It will not upset all our commercial calculations. Business will increase, upon the general announcement that this lamp is coming into use, faster than you can get the lamps to put into service.

Mr. W. H. Gardiner, Jr. (Boston): As I remember the figures, the introduction of the tantalum lamp will show a loss of current consumption, owing to the size of the lamp, 22 candle-power over 16 candle-power, of only about 20 per cent. The gain in individual candle-power per lamp will, I think, be a very advantageous thing. The 16-cp lamp was introduced at a time when other illuminants—gas, for instance—were of a lower candle-power than at present, and before the extended introduc-

tion of incandescent gas lighting. Therefore, the unit of illumination in the tantalum lamp shows up approximately on the same basis as its competitors. To-day we have 25-cp gas in a great many places, and we also have the incandescent gas lighting, which is very much more brilliant; consequently, it is very usual that one has to light two 16-cp lamps in order to get the same illuminating effect. Therefore I should say that we ought to welcome this increase in the size of the lamp, even if accompanied by a slight decrease in current output. That is only about 20 per cent. I will add, in this connection, that the gas industry had a very much larger decrease to face. They had formerly, with gas at 25 candle-power, consumed five feet to the burner per hour, but when the incandescent lamp came in the consumption went down to three feet and the candle-power went up to, say, 50. That was a very much greater difference, a greater drop, and some gas managers were not very quick to recognize the point, but I think it is now generally accepted that it is to the advantage of the gas manager to use the incandescent gas mantle rather than the open flame, in spite of the shrinkage in consumption of 40 to 50 per cent. I think we should welcome the tantalum lamp.

THE PRESIDENT: The next paper is entitled *The Paramount Importance of the Selection of Standard in Preference to Special Machinery*, by Mr. David Hall, of Cincinnati.

Mr. Hall read the following paper:

THE PARAMOUNT IMPORTANCE OF THE SELECTION OF STANDARD IN PREFERENCE TO SPECIAL MACHINERY

The idea of this paper is to call your attention to the important advantages, to both purchaser and manufacturer, in the use of standard, in preference to special, machinery. This is not a case in which the manufacturer alone is benefited; the points of advantage are mutual. The purchaser in selecting standard machinery aids the manufacturer in producing a more efficient and a more perfect machine at a lower cost.

The most successful power plants must be characterized by reliability and economy of operation. There must be machinery sufficient to meet all emergencies, and the machinery should be of as simple construction as possible, as simplicity is the key to reliability and complications insure troubles. The experimental stages of machinery of all kinds are examples of how complicated apparatus can be made, while its ultimate success depends upon the eradication and simplification of the parts so that the machine as a whole is easily understood and easily operated. With the advent of a new machine, we say "how complicated"; when the same machine is perfected, we say "how simple." It is therefore to the advantage of the purchaser that machinery become standardized. If only one machine is built from each design, and we have an infinite number of designs, the result is an infinite number of experiments, and it is only after one of these machines is thoroughly tried and perfected that we have a machine which can be called standard. However, if we assume that no two machines that are purchased are to be alike, there would be no incentive for standardization. This paper refers to "standard machinery" as machinery that is regularly listed for sale by a reputable company, such machinery having been built and standardized. The first machine of almost any description is capable of being improved upon. Sometimes the improvements suggest themselves after a very short test, while other improvements may be made only after a long period of operation. In fact, it may be said that the longer a machine of a given type is operated, the more certainly

can the good points be determined and the more pronounced are the bad features that are to be overcome. Consequently, it is positive that the purchaser has everything to gain, in so far as operation is concerned, by selecting machinery that is standard and does not possess experimental features.

It is to the interest of the purchaser and operator of every machine to know that spare parts can be readily obtained, for in the operation of machinery in general there are certain to be requirements for new parts, made necessary on account of wear or accident, and it is usual that such parts are wanted on short notice. If the machine is standard, such parts are likely to be found in stock, or, at any rate, can be furnished quickly. On the other hand, if the machine is of special construction in part or throughout, there is great probability of delay, and such delay may be very expensive as well as annoying. In fact, a long delay may cost more than the machine is worth.

In the natural course of events in the operation of mills, factories, and power plants, changes of help are continually taking place and there is no machine so simple that the experienced operator can not produce better results with it than can the inexperienced. It is, therefore, of importance that machinery be of such a nature that it can be easily operated, and this point must not be overlooked in making machinery standard. The more machines there are in operation of a given kind, the more men there must be who are familiar with operating them and, consequently, the easier it must be to obtain an experienced operator.

Delivery of machinery is usually second in importance only to price, and it is not a rare occurrence that delivery is even more important than price. That standard machinery can be delivered more quickly than special machinery needs no proof. At the same time it is not always so plain to the purchaser why a special request as to speed, exact output, or detail of construction of a machine may delay its delivery three months, whereas a standard machine differing only slightly from the specifications might have been delivered immediately. At the same time the standard machine might meet the requirements and do the work as well as, or better than, the special machine. Change of designs, change of drawings, new patterns, new tools, and new castings, are matters that are given little thought or consideration by the purchaser, yet these are the things that keep the non-productive element of a

ago I had occasion to write a specification for a 300-kilowatt alternating-current generator, 25-degree rise. Among the four bidders there was only one that had the generator at the required speed and size, and one of these wanted us to accept the machine at a given atmospheric temperature of 25 degrees centigrade. We received bids from three or four manufacturers, each one bidding on a different machine as to size or speed. Within a week or two I had occasion to ask for bids on a half-dozen 30-kilowatt induction motors, with a speed of 450 revolutions. There was not one manufacturer who could produce the machines within ten weeks, because they all said it was special machinery. What we want is to have machines that are not special, but we also want apparatus suited to our needs and conditions.

MR. H. T. HARTMAN (Philadelphia): One point brought out in the paper is the number of different speeds that are asked for for one size of generator. I think the trouble in that respect is largely due to the fact that each engine builder has his speed for that special output, and the purchaser, if he wants a special style of engine, must specify the speed that the engine builder calls for. If the electrical manufacturers were to get together and standardize their speeds, and at the same time consult the manufacturers of engines, a standard could be arrived at that would be satisfactory under almost all conditions.

THE PRESIDENT: If there is no further discussion on the paper we will proceed to the next paper, which is on *Insulation Testing—Apparatus and Methods,* by Mr. C. E. Skinner, of Pittsburg.

Mr. Skinner presented the following paper:

INSULATION TESTING—APPARATUS AND METHODS

Among the tests which are regularly made to determine the quality of a piece of electrical apparatus is that known as the disruptive or dielectric test on the insulation. Modern practice indicates the desirability of making these tests on the materials, on the parts of the apparatus, and on the completed apparatus. The users of electrical machinery frequently include such tests among those which must be made for the acceptance of the apparatus. The American Institute of Electrical Engineers has recommended a schedule to be followed in the making of dielectric tests, this schedule setting the voltage limits, but not indicating apparatus and methods.

It will be the writer's endeavor to discuss briefly the elements that should be considered in the design, selection and use of apparatus for making dielectric tests.

TESTING APPARATUS

By far the greater part of such tests are made by means of step-up transformers. The static machine may be employed to advantage in some cases, and occasional tests are made by the use of direct current such as may be obtained from an arc-light machine; but as these cases are special, they will be omitted from the discussion, and only testing apparatus employing alternating current, either direct from the generator or through step-up transformers, will be considered.

In the design and selection of apparatus for making disruptive tests a number of points must be taken into consideration, among which are the following:

(1) Maximum testing voltage.
(2) Frequency of the testing circuit.
(3) Static capacity of apparatus to be tested.
(4) Variation of the testing voltage.
(5) Measurement of the testing voltage.
(6) Provision for locating faults.
(7) Portability of testing apparatus.

(8) Rating of testing transformers.

The items above will be discussed in detail in the order given.

(1) MAXIMUM TESTING VOLTAGE

The maximum testing voltage required depends on the nature of the material or apparatus to be tested. For the lower voltage apparatus, the testing voltage is usually several times the normal rated voltage of the apparatus. For the higher voltages, the testing voltage is rarely much more than double the normal rated voltage. In testing materials, almost any voltage or any range of voltage may be required, from a few hundred volts to 100,000 or 150,000 volts. For direct-current street-railway work, tests above 5000 volts are rarely required, and tests from 2000 to 2500 volts are more common on finished street-railway work. Apparatus for 2000-volt lighting service requires tests of 4000 to 10,000 volts. In high-tension transmission work the test is usually from one and a half to two times the normal rated voltage of the apparatus. The highest e.m.f. in use at the present time for long-distance transmission work is approximately 70,000 volts. Tests requiring double this voltage are not at all uncommon.

When the investigation of insulating materials is to be undertaken, testing apparatus giving any voltage up to 150,000 will find frequent use, and for a complete understanding of the work, occasional tests of 200,000 to 250,000 volts may be required on special insulators or combinations of insulation for the higher voltage service. Testing apparatus capable of giving half a million volts or more is merely a scientific curiosity at the present time. Tests of 100,000 to 150,000 volts will cover any commercial work, even to the most exacting line insulator tests, and 250,000 volts should be sufficient for any investigation necessary in connection with commercial work. A well-equipped high-tension laboratory should have apparatus capable of giving any electromotive force from a few hundred volts to the commercial maximum mentioned above.

The following table gives a list of maximum testing voltages suitable for various classes of work, together with the capacity in kilowatts which will be found sufficient for most work for each maximum voltage. Special work, such as cable testing, may require a greater transformer output, as will be discussed later.

Maximum Testing Voltage	Capacity in Kilowatts
2,000	1
6,000	3
10,000	5
30,000	30
50,000	50
100,000	100
150,000	150
250,000	250

The above are arbitrary divisions that have been found convenient in practice. The ratings given are the continuous ratings based on temperature rise.

(2) FREQUENCY OF THE TESTING CIRCUIT

The frequency of the circuit on which a testing transformer is used determines in some measure its size for a given output—the lower the frequency, the larger the transformer required. A more important consideration governing the output for a given test follows from the fact that the amount of charging current to a piece of apparatus considered as a condenser varies directly as the frequency of the testing circuit. Consequently, the higher the frequency, the larger must be the testing transformer for making tests on apparatus having a given capacity in micro-farads and at a given voltage. Furthermore, the dielectric loss in insulation at a stress approaching the disruptive strength also varies approximately as the frequency, requiring additional testing capacity where this feature becomes a measurable factor.

It may be stated, therefore, (1) that for a *given output,* the lower the frequency, the larger the transformer required, and (2) that for a *given condition of test* a larger output testing transformer will be required for high than for low frequencies.

(3) STATIC CAPACITY OF APPARATUS TO BE TESTED

Small samples of insulation require but a very small output in the testing transformer, but with large machinery or cables a much larger output is required, on account of the current necessary to charge the apparatus or cable, considered as a condenser. The formula for the flow of current to a condenser when a sine wave electromotive force is applied to its terminal is as follows:

$$I = 2\pi \times 10^{-6} \times E \times C \times N$$

Where I = current in amperes,
E = volts,
C = microfarads,
N = cycles per second.

The charging current therefore varies directly as the frequency, directly as the voltage, and directly as the static capacity; and as apparent energy is equal to current multiplied by voltage, it follows that the apparent output of the transformer required must vary directly as the frequency, directly as the square of the voltage, and directly as the static capacity (in micro-farads) of the apparatus under test. Little or no additional transformer capacity is required for ordinary testing beyond that supplying charging current as shown by the formula above, and, with the small additions noted below, the output of a testing transformer may be based on the formula given, when the static capacity of the apparatus to be tested is known.

There may be slight I^2R losses in poor insulation due to current actually flowing through it, but the amount will be very small and practically negligible. The dielectric loss in the insulation is usually relatively small as compared with the charging current, and for all practical purposes it may be left out of consideration in the design of testing transformers.

Measuring devices, such as a direct-reading type voltmeter, in series with a resistance, on very high-tension circuits may take a sufficient amount of power to require consideration. For example, an ordinary alternating-current voltmeter in series with the necessary multiplying resistance on a 100,000-volt, 25-cycle circuit will require approximately six kilowatts to operate the voltmeter at full scale deflection.

The requirement of the Committee on Standardization of the American Institute of Electrical Engineers relative to transformer output required in dielectric tests is, that "the source of alternating e.m.f. should be a transformer of such size that the charging current of the apparatus as a condenser does not exceed 25 per cent of the rated output of the transformer." This requirement seems to be based on some idea that there will be an undue rise of potential in the testing circuit unless the testing transformer output is very large. This is not borne out in

practice, and it is the writer's observation, confirmed by that of others, that satisfactory tests can be made up to the full current rating of the testing transformer if the testing voltage is measured in the high-tension circuit. Modern testing transformers are as well designed as transformers for other purposes, and the American Institute of Electrical Engineers' requirement would fre-

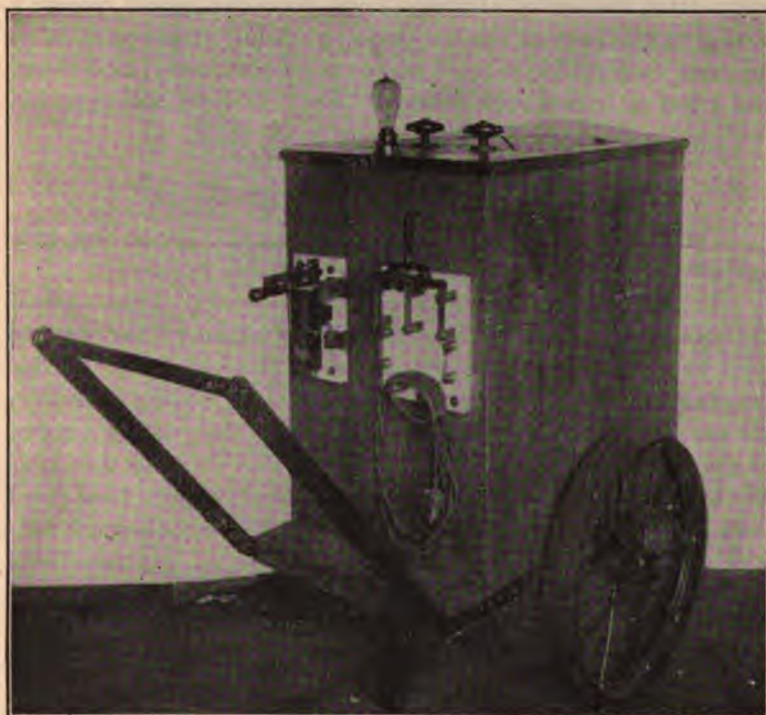


FIG. 1—5-KW, 10,000-VOLT PORTABLE TESTING SET

quently necessitate the use, especially in cable testing, of a testing transformer having an output greater than is usually available for such work.

As examples of the minimum capacity that could actually be used, giving full rated load to the testing transformer, the following may be cited: The first 5000-hp generators for the Niagara Falls Power Company have a capacity of approximately 0.3 micro-

farad. The test voltage was 6000, and the minimum testing capacity required at a frequency of 25 cycles would therefore be 1.7 kilowatts. The 5000-kw generators of the Interborough Rapid Transit Company have a capacity of approximately 0.6 micro-farad, and the test voltage was 25,000, requiring, therefore, a testing transformer of at least 50-kw capacity at a frequency of 25 cycles. An underground cable having a static capacity of one micro-farad and tested at 20,000 volts, 60 cycles, would require a testing transformer of 150-kw capacity. A test at 40,000 volts on the same cable would require four times this capacity, or 600-kw, and a test at 60,000 volts would require nine times this capacity, or 1350-kw, as shown by the formula given above.

(4) VARIATION OF THE TESTING VOLTAGE

There are three principal methods of varying the testing voltage when making dielectric tests. These are as follows:

(*a*) *By varying the field of the generator.* This method assumes that the generator and the testing transformer may be used as a unit. This method of variation gives a considerable range of testing voltage, depending on the design of the generator, the amount of field resistance available, and the relative amount of charging current required in the test. This variation may usually be depended upon to be from 50 per cent of the normal rated voltage of the generator to a slight amount above the normal voltage. The variation of the testing voltage by the generator field is unsatisfactory when the charging current is large and the field current very low, for the reason that the charging current passing through the armature reacts on the field and causes an unsteady condition of the voltage, which is very undesirable. With this exception, the variation of the field of the generator is the most satisfactory method that can be followed, within the limits given above. This general plan is shown diagrammatically in Figure 6.

(*b*) *By means of a resistance in series either with the primary or the secondary of the testing transformer.* This method assumes that the source of supply is a constant-potential circuit. The type of resistance most frequently used consists of a water rheostat of some form, although any convenient resistance can of course be used. For small testing capacities this method is quite satisfactory, particularly if means are at hand for measuring the testing voltage in the high-tension circuit. For large capacities, the

resistance becomes either very large if used in the primary, or very difficult to build and insulate if used in the secondary. Water resistance must be of such capacity that there will be comparatively little formation of gas on the resistance plates, as this formation

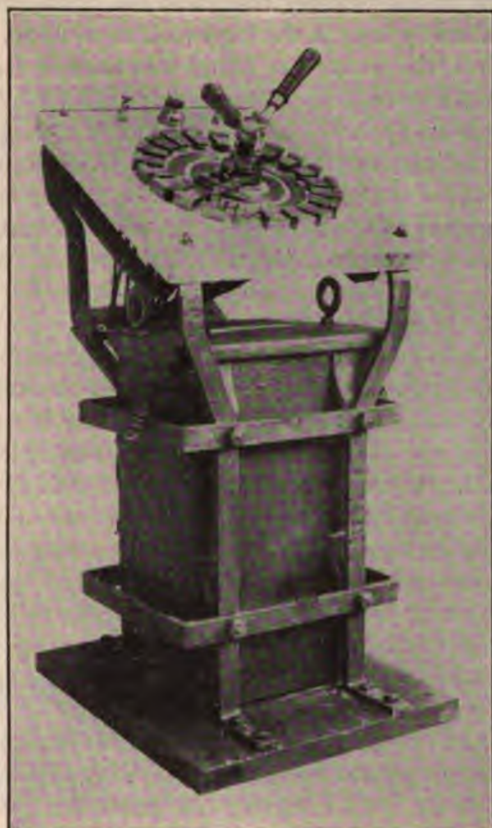


FIG. 2—25-KW REGULATING TRANSFORMER GIVING 5 PER CENT STEPS

may cause intermittent variations of the resistance and consequent undesirable variations in the testing circuit. This requires a large capacity water rheostat. The principal advantage of this method of control is its cheapness. Its disadvantages are the large size of water rheostat required, the intermittent variation of voltage

apparently due to the formation of gas from the decomposition of the water, the change of the e.m.f. wave to a more peaked form, and variation of the voltage due to the change of resistance as the water becomes heated and evaporates.

For general plan see diagram Figure 7, where a water rheostat is shown in the primary circuit of the transformer, with a further variation by taps in the high-tension winding.

In general, the writer has found this method far less satisfactory than the method about to be described.

(*c*) *Variation by steps.* A very considerable range of testing voltage may be obtained by bringing out loops from the high-tension side of the testing transformer, with further combinations of the low-tension windings. This plan requires that the testing circuit be broken from step to step. Diagrams 8, 9, 10 and photograph, Figure 1, show such arrangements suitable for low-voltage testing.

Very close regulation of the testing voltage may be obtained by the use of a second transformer, which may be called a regulating transformer. The regulating transformer is connected direct to the line and has a large number of loops in its secondary winding, which are connected through suitable dials to the primary of the testing transformer. This transformer may be wound with a primary and secondary, or may be of the auto type. A single dial arrangement is shown diagrammatically in Figure 12, and a photograph of a 25-kw auto-regulating transformer with dial is shown in Figure 2. A double dial arrangement, giving still further refinement as to the gradation of the voltage, is shown diagrammatically in Figure 13.

Figure 3 shows photograph of a portable double dial set of 30-kw capacity at 30,000 volts, complete with switch, fuses, circuit-breaker, choke coil for burning out faults, etc. With this arrangement it is customary to make the total range of the small step dial equal to two steps of the main dial. For quick adjustments the small step dial may be set at its middle point and the test voltage set approximately by the large step dial, final close adjustment being obtained by the small step dial. With twenty points in each dial, steps of 0.5 per cent are obtainable over the whole range from 0 to 100 per cent. A feature of this scheme that may be objectionable in the most exacting work lies in the fact that the small step dial must be returned to the zero point for

each large step when changing the voltage over a wide range by small steps, or there will be a succession of small and large steps. This difficulty may be entirely overcome by the use of a third, or auxiliary, regulating transformer, as shown in Figure 14. An inspection of this diagram shows that it is in effect the same as the double dial arrangement with the exception that provision is

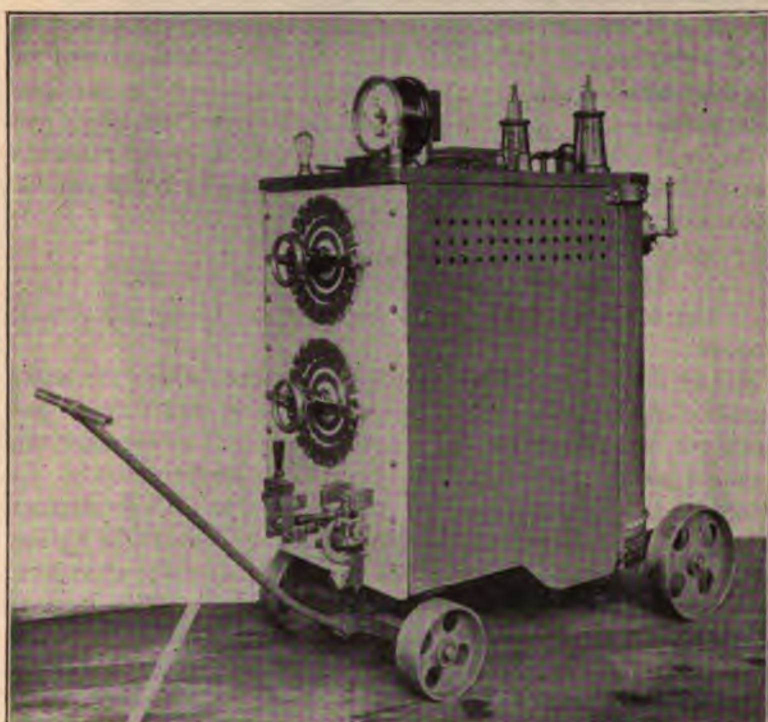


FIG. 3—30-KW, 30,000-VOLT TESTING SET COMPLETE

made for connecting the small auxiliary regulating transformer across any consecutive pair of taps in the main regulating transformer and then varying the voltage across this pair of taps by very small gradations.

As the direction of the current is reversed in the auxiliary transformer with each large step, a continuous increase or decrease in the voltage of the testing transformer by the smallest steps

without opening the circuit may be effected by moving the auxiliary dial over full range, then moving the main dial one step, then reversing the auxiliary dial over full range, etc. Twenty points on each dial gives steps of one-fourth of one per cent from 0 to 100 per cent without opening the circuit. Figure 4 shows complete regulating transformer with oil-insulated dials, instruments, etc., and Figure 5 a 200-kw, 150,000-volt testing transformer used in connection with this regulating set.

A still further variation of the voltage may be obtained in most transformers by providing a symmetrical arrangement of the high-tension windings, which may be connected in multiple, multiple-series, or series. Four equal combinations will give three voltages at which the transformer may be used at its full rated capacity, these being 25 per cent, 50 per cent and 100 per cent of the maximum rated voltage.

(5) MEASUREMENT OF THE TESTING VOLTAGE

The following methods are used for measuring the testing voltage:

(*a*) *By ratio.* In the lower-voltage work, where the static capacity of the apparatus to be tested is small and extreme accuracy is not necessary, the simplest method is to measure the primary voltage and multiply by the ratio of transformation. In making a large number of tests, as is required in the manufacture of electrical apparatus, it is usually sufficient to connect the testing set to mains carrying a known difference of potential and assume that the results will be sufficiently close to ratio. This method will be found inaccurate when the electro-static capacity of the apparatus under test is large, a rise of the voltage in the testing circuit usually resulting when the output of the testing transformer is sufficient to carry the current without serious drop in voltage. Even when the voltage is measured directly in the testing circuit, a voltmeter in the low-tension circuit will be found a great convenience to check the readings.

(*b*) *By voltmeter readings in the high-tension circuit.* The reading may be taken across the whole or only a part of the high-tension windings. Direct-reading voltmeters of the current-operated type used in series with a non-inductive resistance may be employed for this purpose. The chief advantage of this method is the ease of calibration, and it has the further advantage that the

voltmeter may be an ordinary instrument supplied with the necessary series resistance. It has the disadvantages that the charging current of the voltmeter resistance may lead to inaccuracies; the voltmeter itself must be covered by a metal case which is connected

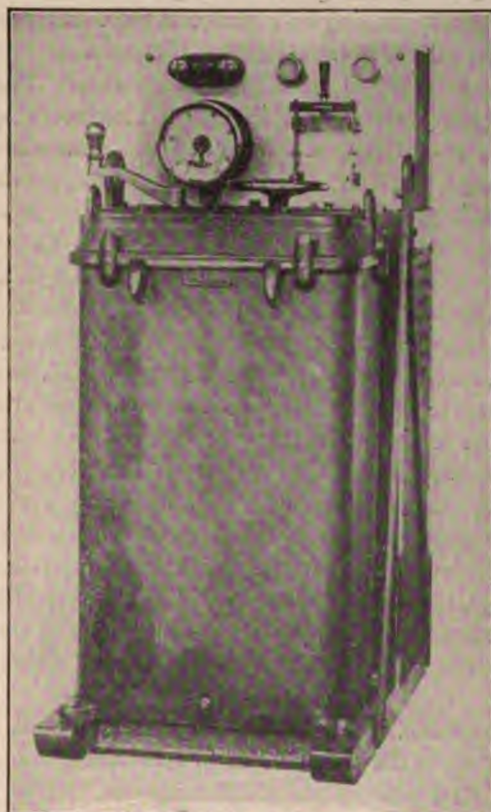


FIG. 4—200-KW DOUBLE DIAL REGULATING OUTFIT COMPLETE EXCEPT TESTING TRANSFORMER

to one terminal of the voltmeter to prevent the static charge from affecting the needle; and the resistance on very high voltages consumes a large amount of power; also, the resistance is clumsy and difficult to insulate.

A static voltmeter in the testing circuit is theoretically the

ideal method of measuring the testing voltage. Unfortunately, static voltmeters reading up to the highest voltages required in testing work are not available. Instruments of this class which the writer has been able to test are either inaccurate or are so delicate in their adjustments that they are constantly getting out of order, also the scale is short, and the range of reading is small. No thoroughly reliable instrument reading up to 100,000 volts under all conditions of service has as yet been placed on the market.

(*c*) *By spark gap in the high-tension circuit.* The committee of the American Institute of Electrical Engineers appointed to consider this matter has recommended the determination of the testing voltage for any given piece of apparatus by the use of a spark gap in the high-tension circuit, this spark gap to consist of sharp needles, the distances for various voltages being given. This method has many disadvantages and few advantages. The testing voltage cannot be determined until the instant of breakdown of the gap, when the test must be discontinued. The voltage measurements are very unreliable unless especially safeguarded by an elaborate set of shields, and there is much controversy as to the actual distances which represent given voltages. When used in the testing circuit with very high voltages, the disruptive discharge caused by the breaking down of the gap may cause serious damage, either to the testing transformer or to the apparatus under test, due to the momentary rise of potential across the outer windings when the spark gap breaks down. In testing transformers and generators the spark gap should always be used in series with a very high resistance or a powerful choke coil.

(*d*) *By special voltmeter windings.* In special cases windings are placed on the transformer in such a way as to give more nearly the actual ratio of transformation that can be obtained by measuring the voltage of the primary circuit. This is really a ratio method, and is somewhat more accurate than measurements across the primary circuit, on account of the position in which the winding is placed and the freedom from drop due to load which is experienced in the regular ratio method.

(*e*) *By voltmeter transformer.* It is possible to use a step-down transformer in the high-tension circuit connected to a voltmeter. This is a satisfactory method where the voltage is low and the output of the testing transformer sufficient to supply the

voltmeter transformer losses, etc. It becomes a very expensive method with very high voltages, for the reason that the voltmeter transformer is very difficult to wind and insulate for such small capacities. For a 60,000-volt voltmeter transformer the mechanical requirements are such that the transformer when built will have a capacity of 15 to 20 kilowatts, while the voltmeter takes only from 15 to 20 watts. The writer is familiar with voltmeter transformers where the losses in the transformer itself were many times the rated output of the transformer.

(6) PROVISION FOR LOCATING FAULTS

In many tests it is very desirable to be able to locate faults that occur under test. One of the most satisfactory methods in the testing of electrical machinery is to hold the testing current a sufficient length of time to produce burning of the insulation at the point of fault, this being located by the smoke which issues from the point. This is particularly true in the testing of windings of transformers and machines. For this purpose a resistance or inductance in some part of the circuit of the testing apparatus is very satisfactory. A convenient method is to provide such a resistance or inductance in parallel with a fuse or circuit-breaker in the primary of the testing transformer, this fuse or circuit-breaker being so adjusted that it will carry the normal testing current until the fault occurs, the increase in current due to the breakdown blowing the fuse or circuit-breaker and thus throwing the resistance or inductance in series with the transformer. The resistance can be so adjusted that approximately normal current will flow through the high-tension windings of the transformer, and when this is done the burning may continue for any desired length of time without injury to any part of the testing apparatus. In the testing of cables it is usually necessary to burn out a breakdown sufficiently to produce a low resistance fault, which may then be located by any of the well known methods. The arrangement of resistance and circuit-breaker for burning out faults is indicated in several of the diagrams shown.

(7) PORTAPILITY OF TESTING APPARATUS

The portability of testing apparatus is entirely a matter of convenience as required by the work to be done. In a large factory it is desirable to have apparatus giving voltages up to

cation of the voltage and the total time of making the test should be the same. The method of measurement should be the same. The constants of the testing circuit—frequency, wave form, etc., should always be the same for comparative purposes.

For sheet material, metal terminals with the edges well rounded to prevent concentration of electro-static flux at the sharp edges, should be used. When the sheets are small and the test voltage low, circular terminals with an area of approximately one square inch with edges rounded to a 0.25-inch radius tangent to the testing surface will give good results. Many tests are made between terminals having spherical contacts, 0.5-inch to one-inch hemispheres turned on the ends of rods being employed. For irregular shaped solids, such as porcelain, the conditions of service should be simulated as far as possible. For example, a line insulator should have a contact similar to that of the line and tie wires, and test should be made to a metal pin, under the assumption that the pin is wet and therefore a conductor; or test may be made by inverting the insulator in a salt-water bath and filling the pin hole with the same solution. For liquids, the oil testing device described in a paper by the writer on *Oil for Insulating Purposes,* read before this association last year, will be found satisfactory.

High temperatures may be produced in insulating material by the I^2R losses when the material has low insulation resistance. In materials such as marble and slate, which may have low insulation resistance due to moisture, the heat caused by the I^2R losses may dry the material to such an extent that the insulating quality is increased as the test proceeds. With fibrous materials the reverse is usually true, as carbonization takes place before the drying-out process is complete.

In testing solids the effect of heat due to dielectric losses is an important factor in the results, particularly when large contacts are used and tests are long continued. For a fuller discussion of this point, see paper by the writer entitled *Energy Loss in Commercial Insulating Materials When Subjected to High Potential Stress,* Proceedings of the American Institute of Electrical Engineers, Vol. 19, page 1050. The heat generated weakens the insulation and breakdown results at a lower voltage than when the time occupied in making the test is short. This will be found particularly true of materials like glass, treated cloth, mica, etc.

Most insulating materials in the solid form decrease in insulation strength as the temperature is raised, and therefore the temperature at which tests are made should be held as nearly the same for different tests as possible.

Aside from the heating effects noted above, the method of applying the voltage when testing samples of material is not of much importance, whether by steps, by gradual rise, or by the application of full voltage at once, where the test is a predetermined amount and the testing voltage not high—say not over 20,000 or 25,000 volts. It is important, for purposes of comparison, that the same method be used for different samples of material of the same general class. As the actual breaking-down point is desired in most tests on material, the voltage must be applied in predetermined steps, or the rate of increase must be such that voltmeter readings can be taken and the exact point of breakdown determined. For low-voltage tests the step-by-step method, keeping the primary voltage constant and determining the test voltage by ratio, is recommended for rapid work. For higher voltages, say above 20,000 or 25,000, the slow increase of voltage, either by steps without opening the circuit or by smooth increments, as by control of the alternator field, gives better results. The voltage may be read by ratio, or by a static or direct-reading voltmeter in the high-tension circuit. No single test should be taken as an index of the dielectric strength of any material, but the average and lowest of many tests should be considered.

In the testing of dynamos, motors, transformers, cables, etc., the static capacity of the apparatus under test becomes of more importance, especially with the higher-voltage tests, requiring larger testing apparatus and greater care in the application of the testing voltage. There will also be greater tendency to variation in the testing circuit due to rise of potential on large static capacity, drop due to overloaded transformers, etc., than with samples of material, hence the ratio method of measuring the voltage is less satisfactory than in material testing.

Furthermore, tests on finished apparatus are usually not made to determine the ultimate breaking-down strength, but to determine whether or not the insulation as a whole will stand a certain predetermined test, allowing a factor of safety over the working voltage, just as a boiler is tested with a certain excess pressure

for the same reason. It is good practice in manufacturing work to test each part as it is finished, as well as the completed apparatus, in order that any defective workmanship or material may be discovered before the parts are finally assembled. The user of the apparatus is concerned only with the dielectric strength of the apparatus as a whole, while the manufacturer is concerned with each individual part as well as the completed product. It is customary in manufacturing work to find the ultimate breakdown strength for each class or type of apparatus, by actual breakdown tests on individual pieces, this showing the weakest point and the necessity for any change in material or design if the ultimate strength is not sufficiently high.

In testing electrical machinery during the course of manufacture it is customary to grade the tests from higher to lower values as the apparatus nears completion. By this method any given test is lower than the preceding, and small variations in the voltage of the line supplying the testing circuit will not cause any difficulty.

Transformers are sometimes tested by their own voltage, this giving a plan different from any of those described above and requiring no testing transformer. In such tests, one side of the high-tension winding is connected to the low-tension and the iron, and then the transformer operated at a potential sufficiently above the normal to give the necessary test voltage. The other side of the high-tension winding is then connected in the same way, and the test repeated. Attention should be called to the fact that in this test the middle part of the winding receives but half the total test voltage to ground and low-tension coils, there being a uniform grading of test voltage along the winding from the middle point to the outer ends.

In making dielectric tests on completed apparatus, the condition of the apparatus at the time of test is a point which should always be considered with reference to the test. Insulation resistance measurements usually give some indication of the condition of the apparatus with reference to dirt and moisture. A high insulation resistance test, however, does not necessarily indicate that the dielectric strength will be high, but a low insulation resistance test usually indicates a low dielectric test, particularly if the dielectric test is long continued.

Long continued tests on apparatus such as dynamos and

motors are considered very inadvisable, unless the voltage of test is very much below the ultimate breaking down strength and the condition of the apparatus with respect to moisture is perfect, as such long continued tests are liable to produce incipient burning at points within the insulation, which may not be discovered by the test.

In the making of insulation tests of all kinds the factor of personal danger should always be considered. The lowest maximum voltage given in the table of testing apparatus earlier in this paper is considerably more than is necessary to cause death. Special care should be taken to protect not only the operator but others in the neighborhood of the apparatus under test. If it is necessary to handle the live terminals at all, only one should be handled at one time, and it should be insulated beyond any possibility of breaking down. The low-tension circuit and the case of the testing set should be grounded whenever possible. Where a regulating transformer is used the intermediate circuit should always be grounded, as well as the frame and case of the transformer. As this circuit is entirely independent of both the source of supply and the testing circuit it can be grounded without affecting either. For this reason the regulating transformer with primary and secondary is preferable to the auto or single coil transformer, although the latter is cheaper for a given output. A very excellent safeguard for the operator is effected by the use of a main switch which is automatically opened and held open by a spring. With this device the operator must hold the switch closed as long as the test is continued.

The necessity for these precautions is so obvious that it would seem hardly necessary to call attention to them here, but the writer has noted the indifference and carelessness customary with those who habitually handle testing apparatus of this class, and it is the purpose of this paragraph to warn such that it is hardly possible for the same individual to make more than one mistake.

DIAGRAMS

The following diagrams give a few of the combinations of generators, testing transformers, regulating transformers, etc., which may be made for testing purposes. These diagrams have been drawn to show fundamental principles rather than actual details, but they are all based on testing apparatus which is in

actual use. The general characteristics of each class are outlined in the note that accompanies each diagram. Attention should be called to the fact that many of the minor details, such as preventive resistances for the dials, voltmeter connections, etc., have been omitted for the sake of simplicity. Where fuses are shown between the main switch and the testing transformer these are considered a part of the testing set, and are used in addition to the main cut-outs which are usually supplied to any branch line, these cut-outs not being shown in the diagrams.

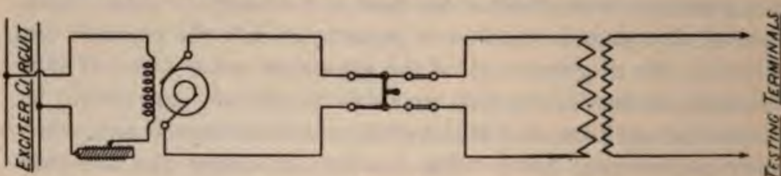


FIG. 6

Voltage regulation by field rheostat of generator. Range of testing voltage, from 50 per cent below to 25 per cent above normal rated voltage of generator, or from approximately 25 per cent to 100 per cent of the maximum voltage of the testing transformer. Suitable for all classes of work and for all capacities of testing transformers.

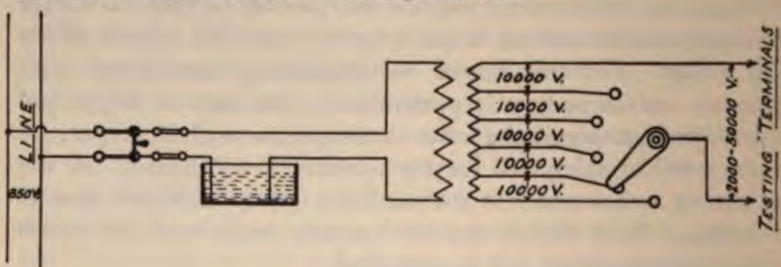


FIG. 7

Voltage regulation by means of water rheostat in series with low-tension winding. Range of variation, from approximately 25 per cent to 100 per cent of the maximum voltage of testing transformer. Suitable for general use, with exceptions noted in text. This diagram shows a further variation of the voltage by means of taps brought out from the high-tension winding of the testing transformer.

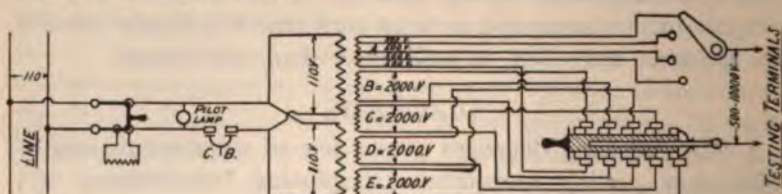


FIG. 8

Voltage regulation by steps in testing circuit. Circuit must be opened between steps. Coils not in use disconnected from testing circuit by special plug switch. Resistance in primary through which circuit is closed to prevent surges. Suitable for general low voltage testing.

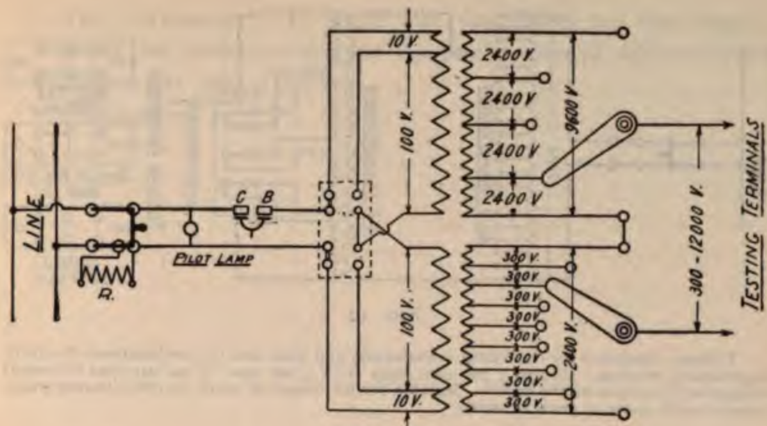


FIG. 9

Voltage regulation by steps in testing circuit. Circuit must be opened in passing from one step to another. Primary suitable for 100, 210 or 220-volt circuit. Range of voltage, from 2.5 per cent of normal to normal voltage, by steps of 2.5 per cent. Suitable for general low voltage testing.

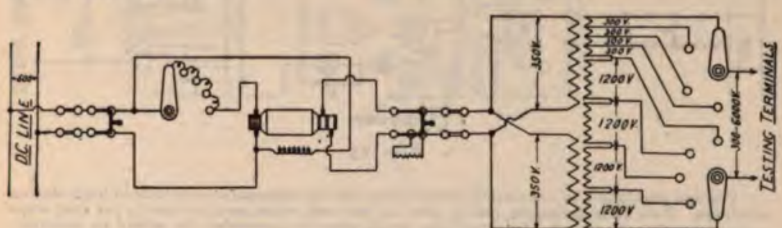


FIG. 10

Direct-current to alternating-current testing set. Direct-current to alternating-current or inverted rotary used to transform 500-volt direct current to 350-volt alternating. Voltage regulation by series resistance in direct-current circuit and by steps in testing circuit. Testing circuit must be opened between steps. Suitable only for small sizes and comparatively low voltage work.

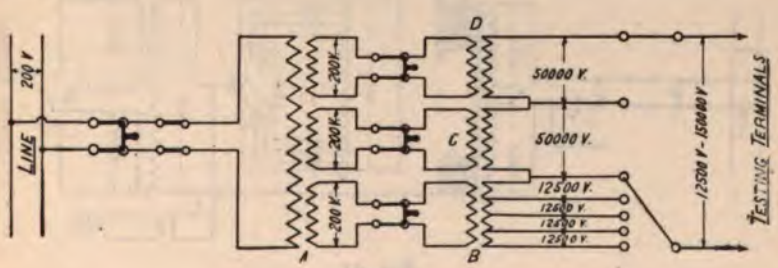


FIG. 11

Voltage regulation by steps in testing circuit. Testing transformer in series with insulating transformer in primary to add insulation to system. Output may be increased on the lower voltages by connecting high-tension windings in multiple. Suitable for use with transformers whose individual insulation is not sufficient for the final testing voltage. Insulating transformer requires high insulation between all coils.

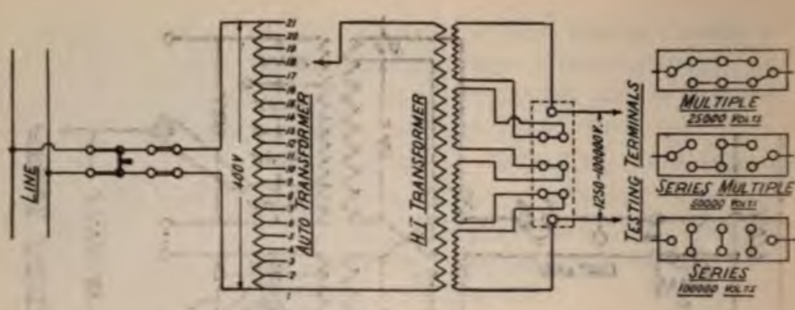


FIG. 12

Voltage regulation by regulating transformer and dial, also by combinations of coils in high-tension winding. Range, 5 per cent steps from 5 per cent to 100 per cent of normal voltage without opening the circuit. Suitable for all classes of work and with testing transformers up to 25-kw or 30-kw capacity.

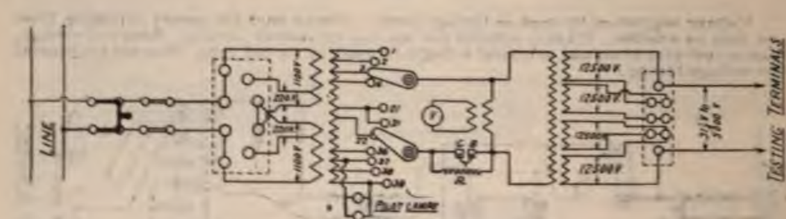


FIG. 13

Voltage regulation by regulating transformer and by combinations of coils in high-tension windings. Two dials, arranged, one to give 0.5 per cent steps and the other 5 per cent steps without opening the circuit. Intermediate circuit may be grounded for safety to operator. Suitable for all voltages and all capacities up to 200-kilowatt.

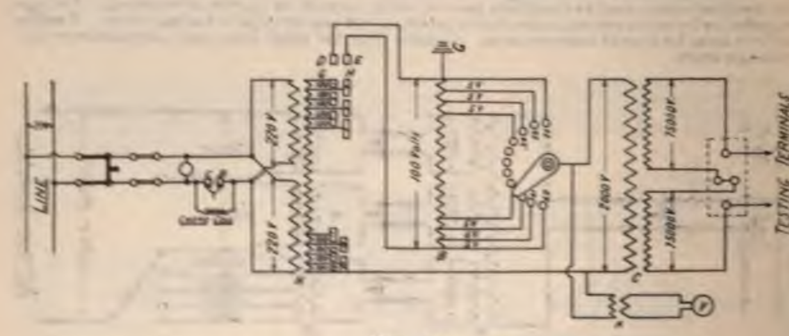


FIG. 14

Voltage regulation by regulating and auxiliary regulating transformers, with double dial. Range, steps of .025 per cent from 0.25 per cent to 100 per cent without opening the circuit. Full equipment of instruments, means for locating faults, etc. This makes an outfit suitable for universal application for sizes up to 250 kilowatts and for any maximum voltage which may be required.

THE PRESIDENT: Is there any discussion on this paper? If no one wishes to discuss the paper we will adjourn until a quarter after two o'clock.

(Adjourned.)

SECOND SESSION

President Davis called the meeting to order at half after two o'clock and announced the first paper on the programme to be that on *Automatic Synchronizing of Generators and Rotaries,* by Mr. Paul MacGahan, of Pittsburg.

Mr. MacGahan presented the following paper:

AUTOMATIC SYNCHRONIZING OF GENERATORS AND ROTARIES

The tendency in central-station development is to eliminate as much as possible the personal element in operation; to introduce labor-saving devices reducing the cost of operation, and automatic apparatus of every description to minimize the amount of attendance required, so as to prevent errors and accidents, and to insure continuous operation.

The synchronizing of generators or rotaries has been the stumbling block in most installations; for a good many years the incandescent lamp method was the only one successfully employed to indicate when the machines were ready to couple. If the lamps were connected across the main switch to similar phases the voltage across their terminals would be a minimum when the machines were in phase, and a maximum when in opposition, thus indicating by their dark period the proper instant for throwing the switch in, and by their flickering or pulsation the amount the incoming machine differed in frequency from the 'bus-bars. When the lamps were cross connected, they would indicate the proper instant when at their maximum brilliancy. Much was left to the judgment of the operator, for the lamp did not indicate whether the incoming machine was too fast or too slow, the illumination was a function of the voltage as well as the phase and, moreover, the darkness of the lamps embraced a very large angle of phase difference. It was necessary to estimate half the time of the dark period, and this was difficult to do, as incandescent lamps have a period of their own, requiring an appreciable time to heat up and cool off. Many will remember the time, and the careful, patient manipulation required to synchronize by means of lamps.

The first improvement in methods of synchronizing was the introduction of the "synchroscope," an instrument that rotated a pointer in synchronism with the difference in speeds of the machines; this instrument has the widest general application to-day, for it gives perfect indications of the phase relation between the machines at any instant, and whether the machine

coming in is too slow or too fast. It does not, however, make an allowance for the time required to close the coupling switch.

The electrically-operated switches generally used for high-tension work, and sometimes even for low-tension work, require a certain definite time to close after the closing current is established. This time varies for different kinds of switches, and the operator has to make an allowance for it in synchronizing, and must close the tripping contact in advance of the actual instant of coincidence of phase, to connect the machines in a safe and satisfactory manner. Moreover, he has to take into consideration the speed at which the synchroscope pointer is approaching the zero point, and make a greater angular allowance on the dial, when the speed is greater. He has to judge what difference in speed gives a safe coupling, and, as a usual rule, will wait until he gets the pointer practically stationary before throwing the switch in. Given a variable speed, or sudden surges in the power in addition to the above variable elements, the operator has to contend with a combination of circumstances, that prevent the synchronization being made quickly and which require a man of judgment to control properly.

Thus it will be seen that if a device could be designed that would automatically respond to the above variables, and close the circuit at the proper instant in a safe and positive manner, the skilled operator could be dispensed with, and the coupling could be done in much less time.

A successful automatic synchronizer should fulfill the following conditions:

(1) It should be certain and safe in its operation.

(2) It should take advantage of the first favorable opportunity for coupling.

(3) It should couple the machines as soon as the difference in speeds is reduced to a safe amount.

(4) It should close the contact in advance of the period of coincidence a sufficient amount for the switch to act, thus coupling the machines at the exact point of synchronism. The greater the difference in speed, the greater should be this advance in angle, in order to make the time allowed constant. As different kinds of switches require different lengths of time to close, the amount of advance should be adjustable.

(5) It should prevent the coupling taking place if the speed of the incoming machine differs too much.

(6) If anything in the mechanism fails, it should prevent the coupling.

(7) It should not close the contact when the machines differ seriously in their voltage, even though in phase. Although a fairly wide difference in voltage is permissible in synchronizing, and will not cause as great a rush of current as a wide difference in phase or speed, it should be nevertheless guarded against. A difference in voltage of 25 per cent may cause a serious interchange of current between the machines; a difference of phase of 15 degrees will generally cause more.

There have been many attempts in the past to devise a satisfactory automatic synchronizer, but none of them heretofore have been successful, as the apparatus did not fulfill all of the above conditions.

One of the best known of the early attempts at automatic synchronizing was the Pearson synchronizer. This device consisted of two controlling magnets mounted in the same case, each magnet serving to close a contact. The two contacts were connected in series with the closing coil of an electrically-operated switch; the magnet coils being connected in parallel, and connected to the incoming machine and 'bus-bars in the same manner as incandescent lamps are connected in synchronizing. One of the magnets was provided with a movable iron core, retarded in its motion by a dash-pot, thus requiring an appreciable length of time to make contact, and operated to select a wave, or "dark period" of the lamps of sufficient length to give the main switch time to act and still render coupling safe. The other magnet had a free, or instantaneous action, adjusted to close its contact only when the voltage across the synchronizer coils corresponded to a coincidence of the phases. Thus in action, the magnet with the time element would close its contact when the difference in speed was small enough and the other magnet would complete the switch-closing circuit when the machines were in exact synchronism.

It will be seen from the above description that the device does not fulfill all of the conditions enumerated; it makes no allowance whatever for the length of time required by the switch to act; it is true that the quick-acting contact may be adjusted to operate at a voltage corresponding to a slight difference in phase so as to make contact ahead of time, but this would mean

that it could make contact the same length of time too late; if the speed suddenly changes after the slow solenoid has closed its contact, there is danger of the second contact closing. Besides, the angular advance of the contact would not vary with differences in speeds, thus coupling the machines at too early a period when they approximated in frequency, and too late when they differed considerably, for the switch requires a constant time to close. These defects alone were sufficient to cause accidents in operation, except under particularly favorable circumstances, and thus rendered the device commercially a failure. However, the inventor deserves great credit for taking the first step in automatic synchronization, and pointing out the advantages that would accrue with a device that would infalliby do the work.

The latest development in automatic synchronizing is a new device perfected very recently by the Westinghouse Electric and Manufacturing Company, which seems to fulfill all the eight conditions above enumerated in a highly satisfactory manner. It differs entirely in its operation from the Pearson synchronizer, which was described quite fully so as to accentuate the features necessary for a successful synchronizer, as well as to throw a light on early progress. This new synchronizer, which is clearly shown in the illustration (figure 1) consists of a pair of solenoids, each actuating a laminated iron core, supported from opposite ends of a rocker arm. Each solenoid is wound in eight separate sections, alternate sections being connected in series, thus forming two circuits in each solenoid; one circuit of each solenoid is connected in series with a circuit of the other solenoid, thus forming two independent circuits in the instrument, each circuit having half of its turns on each solenoid (see figure 2): one circuit is connected to a pair of binding posts deriving current from the 'bus-bars, and the other circuit to binding posts connected to the incoming machine. The connections of the various sections are so made that when the incoming machine is in phase with the 'bus-bars, the currents in the right-hand solenoid (figure 1) act in conjunction, thus pulling down the core, and the currents in the left-hand solenoid neutralize or cancel each other magnetically, and produce no pull. On the other hand, when the machine is in opposition to the 'bus-bars, the currents in the right-hand solenoid neutralize,

and the left-hand solenoid exerts a pull, its currents acting in conjunction.

The cores are suspended so as to reach the magnetic neutral of the coils at their extreme down stroke; thus, when the machines differ in speed, the horizontal beam rocks to and fro, with a harmonic motion. As the incoming machine approaches the frequency of the 'bus-bars, the motion becomes slower, and finally ceases when the machines are at the same frequency; if

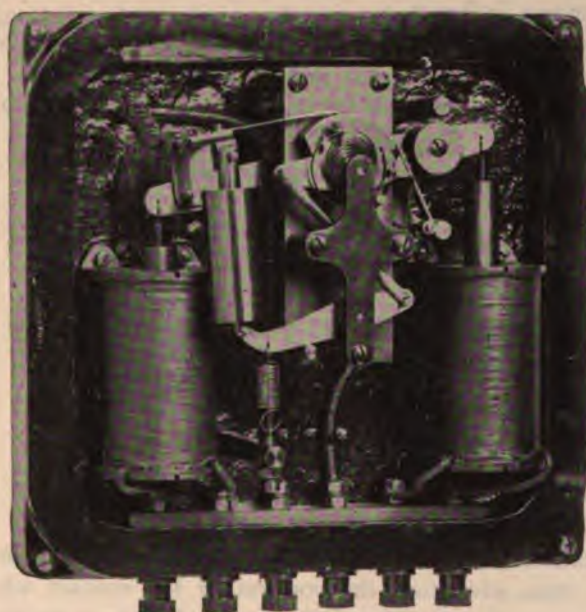


FIG. 1—AUTO-SYNCHRONIZER WITH COVER REMOVED

the machines are in phase the right-hand core will stop at its lowest position, unless the voltages differ considerably, when the currents will not neutralize, and the core will not be able to reach its extreme stroke. The left end of the rocker arm carries a contact spring, marked *A* in figure 3, which slides along the top of a fibre segment *B*. This segment has a platinum strip *C* on the top, which in conjunction with the stationary spring *D* forms the contacts of the relay circuit. The springs and contact are of such length that when the segment is stationary

contact can only be made when the right-hand core has reached its extreme position.

The vital characteristic of this instrument—the one that makes it successfully cover the requirements given for automatic synchronizing not heretofore met—is the peculiar motion imparted to the contact segment. Instead of being stationary, it is pivoted on a shaft concentric with the rocker-arm shaft, which latter on its left half carries the chamber of a dash-pot, the motion of whose piston is opposed by a spiral spring, in the manner shown in figure 3.

When the left end of the rocker arm rises, it tends to lift the piston of the dash-pot, and elongate the spring E. Upon the return stroke a valve in the dash-pot opens, allowing a quick return motion.

The piston rod of the dash-pot carries an arm F, which

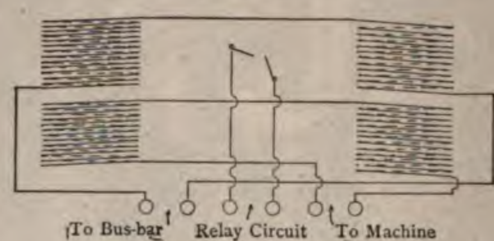


Fig. 2—Schematic Diagram of Internal Connections

is so attached to the contact segment as to shift the latter to the left, thus advancing the position of the contact when the rocker arm moves up with a sufficient speed to draw up the dash-pot piston. The slower the motion of the rocker arm, the less the piston of the dash-pot is raised, and consequently, the less the contact segment is advanced.

It will be noted from figure 3 that the arm F does not act directly on the segment, but operates a brass fork G between the prongs of which is a pin H, which is screwed into the contact segment. There is a spiral spring K between the contact segment and the fork which tends to keep the pin against the right prong of the fork. The pin has thus about one-eighth of an inch of play, the purpose of which will be apparent later.

Turning our attention to the right-hand, or stationary, con-

tact spring, it is seen in figure 3, that this spring carries a cam *L*, the inclined edge of which is met by the pin *M* upon the return stroke of the contact segment. This stationary contact spring is of such strength that the pin *M* can not raise the inclined edge of the cam, for the contact segment is being actuated through the weaker spring *K*. Thus upon its return stroke, the contact segment is delayed for an instant, until the left prong of the fork *G* touches the pin *H* and thus forces up the cam. As soon as the pin *M* reaches the end of the inclined plane, the contact segment is free, and is snapped over by the spring *K*.

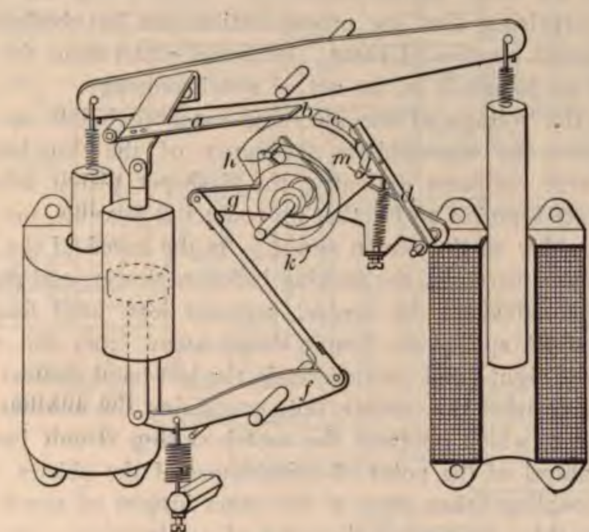


FIG. 3—CONTACT MECHANISM

The purpose of this action will be apparent later. It will be noticed in figure 3, that the position of the stationary or right-hand contact spring can be varied. This, in conjunction with the adjustment of the spring *E*, is for the purpose of adjusting the difference in speed of the incoming machine at which the synchronizer will couple. Thus, when the difference in speed is too great to allow safe coupling, the dash-pot piston will advance the contact segment sufficiently to drop the stationary spring away from the contact plate and down upon the insulated portion of the contact segment *N*, thus preventing the contact

from being closed when the right-hand core comes down. The retarded motion of the contact segment prevents contact being made as the right-hand core rises, allowing time for the left contact spring *A* to get out of the way.

The above descriptions of the actions of the various parts may seem very complicated, but it must be remembered that the instrument has a very complex function to perform. Indeed, an observer of its action in actual service said that it acted in a manner almost human. It is, in fact, more reliable, quicker, and couples the machines with less surge of current than can be done by the most skillful operator. Considering this fact, it seems surprising that the proper action can be obtained with such a small number of parts. To better understand the operation, let us follow it in the act of synchronizing.

As the voltage of the incoming machine builds up and it approaches the approximate frequency of the 'bus-bars, the rocker arm oscillates violently, the dash-pot piston advancing the contact segment so far that no contact is possible, no contact being possible on the return stroke. As the speed of the incoming machine increases, the rocking becomes slower, and the dash-pot piston advances the contact segment less, until finally the right contact spring no longer drops away from the contact, and as the right-hand core descends the left-hand contact spring advances to meet the contact, thus energizing the auxiliary relay in figure 4, which operates the switch-closing circuit just sufficiently ahead of the point of coincidence of the phases, so that actual coupling takes place at the exact instant of synchronism. If the machine approaches the point of synchronism more slowly, there is less advance of the contact segment, and the actual time allowed for the switch to act is the same as before. In the extreme condition, when the machine is coming in very slowly, there is no appreciable advance of the contact segment, the dash-pot having time to exhaust. The amount of the advance of the segment can be adjusted to suit switches having different times of closing, by varying the tension of the spring *E*.

As pointed out before, the cores can not attain their extreme position and therefore the contacts can not be closed if the voltage is too far out for safe coupling.

The auxiliary relay takes very little energy, so there is not enough sparking on the platinum contacts of the synchronizer to burn them.

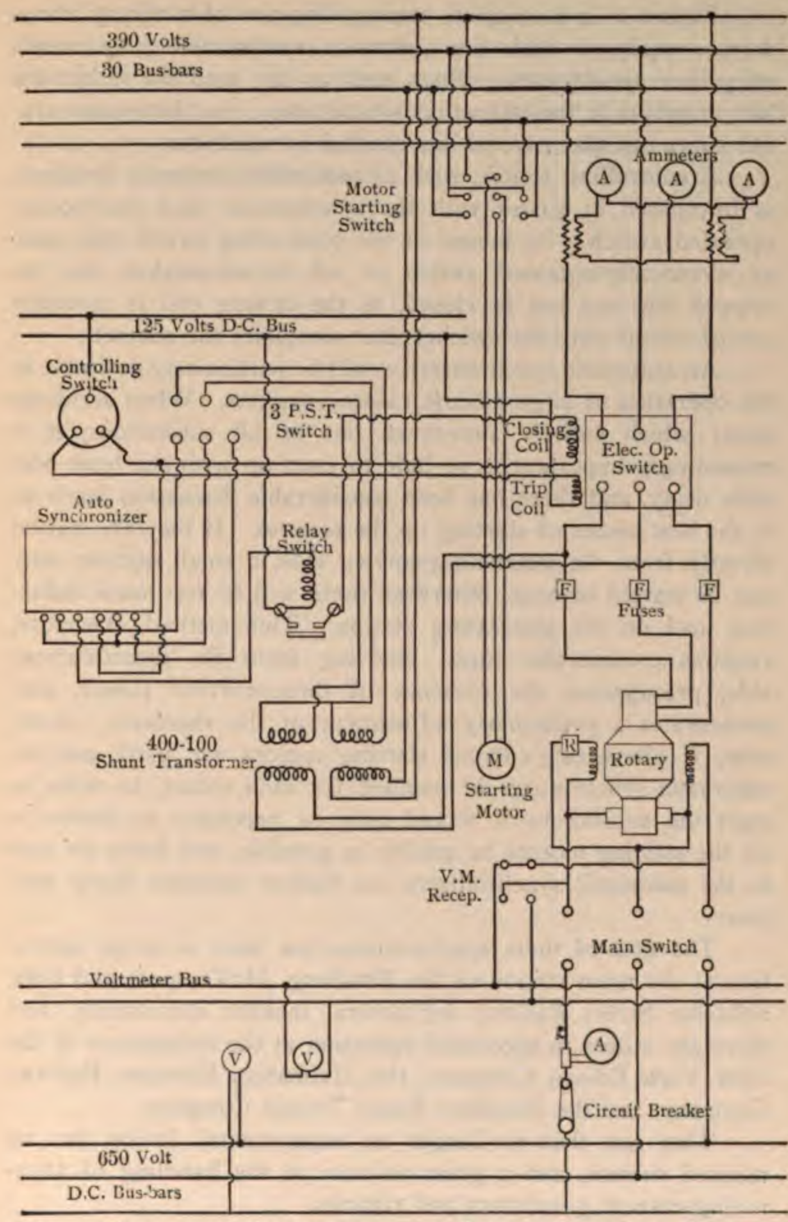


FIG. 4—DIAGRAM OF CONNECTIONS OF A ROTARY CONVERTER EQUIPPED WITH AN AUTOMATIC SYNCHRONIZER

Figure 4 is a complete wiring diagram of a rotary transformer equipped with the automatic synchronizer; by means of proper synchronizing plugs such as are used for either the lamp method or the indicating synchroscope, one automatic synchronizer can take care of any number of machines.

A controlling switch, such as used with oil circuit-breakers, is interposed in circuit with the synchronizer and electrically-operated switch. By means of the controlling switch, the main or electrically-operated switch or oil circuit-breaker may be tripped, but can not be closed, as the closing coil is normally out of circuit until the synchronizer completes the contact.

An automatic synchronizer would be particularly desirable in the operation of large electric railway systems. When accidents occur which entirely shut-down one or all substations, it is exceedingly important to be able to start up with the least possible delay, and there has been considerable discussion lately as to the best means of starting up the rotaries. If they are started directly from the alternating-current side, a small number only can be started at once, otherwise there will be too much inductive load on the generating station. This method, therefore, requires considerable time. Starting from the direct-current side, presupposes the presence of direct-current power, and necessitates a preliminary adjustment of the rheostats. However, if alternating-current starting motors are used, and an automatic synchronizer is installed for each rotary, in order to start the substations it would only be necessary to throw in all the starting motors as quickly as possible, and leave the rest to the automatic synchronizers, no further attention being necessary.

The first of these synchronizers has been in actual operation at the main station of the Pittsburg, McKeesport and Connellsville Street Railway for several months successfully, and there are others in successful operation at the substations of the New York Edison Company, the Manhattan Elevated Railway Company, and the Brooklyn Rapid Transit Company.

They are thus no longer an experimental device, but an assured success, and a great advance in the handling of alternating-current generators and rotaries.

THE PRESIDENT: This paper is now open for discussion. Does any gentleman wish to make any remarks on the paper just read? If not, we will proceed to the next paper on the programme, which is entitled *Notes on Rotary Converters and Motor-Generators for Lighting and Power Systems,* by Mr. Louis E. Bogen, of Cincinnati.

The following paper was read by Mr. Bogen:

NOTES ON ROTARY CONVERTERS AND MOTOR-GENERATORS

A noted statesman has said, "The progress of a country depends upon its roads." The steam road and the wagon road have been mutually helpful in bringing the country into the town, but it has remained for the electric road to broaden out the town to occupy the country, taking progress and a demand for "more light" with it. It is no longer found necessary to have manufactories in the very heart of a city, since employees can readily go to them from all directions. This has changed our systems of distribution of electrical energy, and will continue to do so. The old 110-volt direct-current and the later 220-volt three-wire system find themselves supplying only the very thickly settled portions of an old community, and they are very hard pressed at that, judging from the ever-increasing demand for machines capable of operating from 230 to 320 volts and more.

It has been the writer's privilege, in making estimates upon inquiries for electrical machinery for the past several years, to note the development of central systems of distribution. An inquiry for a 500-kilowatt, 120-volt generator is now a rarity. For 240 volts there is naturally still a call for machines as large as 2500 kilowatts. But we find that when a demand for an increase in power occurs, the want is more and more frequently being supplied by installing alternators, in anticipation of the demand for power and light at greater distances from the station, together with means for tiding over the wants nearer the station. It is not at all intended here to convey the idea that the use of direct current is already obsolete, but that, because of the necessity of distributing over a much greater area, it will be restricted to its own peculiar field of local distribution over a limited area.

This brings us, then, immediately to the consideration of means for the conversion of alternating into direct current, as well as the reverse.

In this country the rotary converter and motor-generator stand out as *the* means of accomplishing the transformation of energy here referred to, although we can not ignore the rectifier, nor can we refrain from expressing our admiration of that ingenious device, the Cooper Hewitt vapor rectifier. Since the question often arises as to whether to install rotary converters or motor-generators, it may be interesting to consider some of the characteristics of each.

Rotaries

In the design of electro-dynamic machinery, the speed is a very important item. For a unit of given output the greater the speed the less the cost, up to a certain limit, beyond which there is again a very sharp increase. There is, therefore, a reasonable speed for any machine of a given rating. In alternating-current machinery there is an additional limitation fixed by the adoption of the standard frequencies of 25 and 60 cycles.

For 25 cycles we find the possible synchronous speeds changing by large percentages. This, together with the fact that at reasonable speeds the number of poles of a 25-cycle rotary is limited, makes it best adapted to the higher e.m.f's., because the current per stud will not be excessive. The 25-cycle rotary is an excellent device for railway circuits as well as for 240 volts. At 120 volts it would have to be operated at a comparatively slow speed to have a commutator of reasonable size.

On the other hand, the 60-cycle rotary, by virtue of its greater number of poles, is better adapted to lower than to higher voltages. In fact, the design of a 60-cycle rotary is limited to such a narrow choice of dimensions as to be almost fixed. We all know what it means to run a commutator at 4500 feet per minute and upward. The brushes can not help chattering. This jumping of the brushes is always attended by slight sparking, due to the breaking of the current, and should the change in load be large enough and the voltage high enough, there will be flashing over from stud to stud. This is especially so because the distance between studs, as well as the thickness of a commutator bar, are both very small, even with the high peripheral speeds used on the commutators. Sixty-cycle rotaries are, therefore, good for 125 volts, passable at 240 volts, but are to be avoided on high-voltage power and railway circuits, where big

changes in load necessarily occur. One flash-over may more than pay for a motor-generator set.

The Casede converter is a device for lessening the troubles on 60-cycle conversion. It is being used in Europe to some extent and consists of a double machine composed of a form of induction motor and a rotary in series. The frequency applied being 60 cycles, for example, if the rotor revolves at half synchronous speed, it will in turn impress a 30-cycle e.m.f. upon the

FIG. 1

armature of the converter proper. The very fact of the existence of such a machine indicates that a want is felt for something better than 60-cycle rotaries. Figure 1 shows a 60-cycle, 240-volt, 360-r.p.m. rotary.

Starting Rotaries

There are a number of methods of starting converters, the

simplest and best method being to start the machine as a direct-current motor from the 'bus-bars, using an ordinary starting box, changing the field strength by means of a field regulator until synchronous speed is reached, when the machine may be thrown on the alternating-current lines. Certainly it can also be run to a point above synchronism and then allowed to fall back to synchronous speed, the direct-current armature circuit having been, meanwhile, disconnected from the direct-current line and, when synchronism is reached, the alternating-current side is thrown on to the lines. This is merely a modification. A simple and convenient method is to start the machine by means of either a direct-connected or geared induction motor having a higher synchronous speed, bringing the machine up to or above synchronism, then connecting it to the lines at the proper time. Another method of starting up from the alternating-current side is to throw the machine on about one-half of the line voltage by means of choke coils or taps in the transformers or an ordinary induction motor compensator. In starting up in this manner, the immense number of turns on the shunt fields form the secondary of a transformer of which the armature, when at rest, is the primary. A very large voltage is thus induced in the shunt fields, and for large machines it is necessary to divide the field winding into a number of sections. This is done conveniently by the so-called "break-up switch." A machine will sometimes "lock" at half voltage when so started. Closing or opening the field circuit will usually remedy this difficulty, because it changes the conditions of operation. In small plants it may be possible to start up the rotaries with the generators from a standstill, leaving them right on the lines.

In starting up from the alternating-current side, the polarity may be either normal or reversed. This may be obviated by noting the action of a direct-current voltmeter connected to the armature. As the armature approaches synchronism so that the frequency is low enough to affect the voltmeter, the needle of the latter will swing violently, first in one direction and then in the other, and finally come to a position indicating either a positive or negative direction of current, showing that the polarity is normal or reversed. An interesting experiment was recently made on a rotary running from half the normal alternating-current voltage. The break-up switch was so arranged that the

fields were short-circuited in pairs of twos. To ascertain whether or not the machine was in synchronism, a disc was attached to the shaft, this disc being divided into eight alternate black and white sectors to correspond to the number of poles of the rotary. An arc light a short distance from the disc was operated from the same source of alternating current. When the disc apparently became stationary, the machine had reached synchronism. When synchronous speed was reached, the fields were thrown across the armature, and if the machine was of the proper polarity nothing further was necessary; but if it came up in the reverse direction, by reversing the field connections by means of a double throw switch, the armature was found to drop out of step and fall back, one-half the pole pitch remaining steady at this point and running at synchronous speed. Under these conditions, the direct-current voltage came down very close to zero. The fact that the machine had not dropped back one complete pole was ascertained by measuring, by means of small copper wires, the voltage from one brush to a point half-way between two brush studs. This was found to be 250 volts. The direct-current brushes sparked badly and the armature leads became very warm, showing that large currents were flowing within the machine. It was then found that upon reversing the field when it was very weak, either self or separately excited, this did not occur, but the armature fell back one full pole when the fields were reversed. This reversing could be much more definitely accomplished when the neutral period of the rotary was ascertained. It was found that when running at synchronous speed, it would take just 11 seconds for this particular machine to fall back one full pole. Therefore, if the machine was found to have the wrong polarity, by opening the alternating-current switch and waiting 11 seconds to throw it in again, 11 seconds after opening it, the machine could be caught in the right position.

Position

Everyone familiar with the operation of rotaries has no doubt observed that there is a certain point at which the machine takes a minimum amount of alternating current for a given direct current that it may be delivering; and that if the field strength be either increased or decreased beyond this point, the alternat-

ing current will increase for the same direct current delivered. This extra current is a wattless one and is leading if the field excitation is more, and lagging when it is less, than the amount required to give minimum alternating current for the given direct-current output. It produces unnecessary heating in the armature, and is therefore to be avoided as far as possible.

Hunting or pumping is an action common to all synchronous apparatus under certain conditions, and indicates a giving and taking of power to or from the line. This phenomenon may be produced by a prime mover having a non-uniform angular velocity, or because the alternator has poor inherent regulation. An armature current of varying power factor may produce a shifting of the fields under the poles of the alternator, which gives the equivalent of fluctuation in speed, even though the speed is constant. Hunting is very frequently induced in a rotary converter by other synchronous apparatus operating upon the same system. The armature of the rotary, being of comparatively small mass, takes on and may accentuate the irregularities in a system, and it is wise to avoid operating the machines in parallel, especially on both the alternating and direct-current sets. In one large system which the writer has in mind the consulting engineers very wisely did not operate the two 1000-kilowatt generators directly in parallel, but connected them beyond the step-up transformers; thus they were enabled to operate a 400-kilowatt rotary in this station directly from each generator and were able to parallel the direct-current ends of these rotaries. The transformers form a spring, or buffer, as it were, and not a rigid lock, as would be formed if the two rotaries were connected directly on the alternating-current side. The rotating element of any dynamo takes a fixed position relative to the stationary element, due to the magnetic pull, and unless there is something to set up a vibration parallel to the axis, the brushes will ride in a fixed position. An ingenious method of producing an end play is shown in Figure 2.

Motor-Generators

Motor-generators, for our purpose, divide themselves into three classes:

(*a*) The combination of an induction motor and direct-current generator.

(*b*) A synchronous machine and a direct-current machine.

(*c*) Two alternating-current machines coupled together for the purpose of changing the frequency in a system.

For small motor-generators, the induction motor-driven set

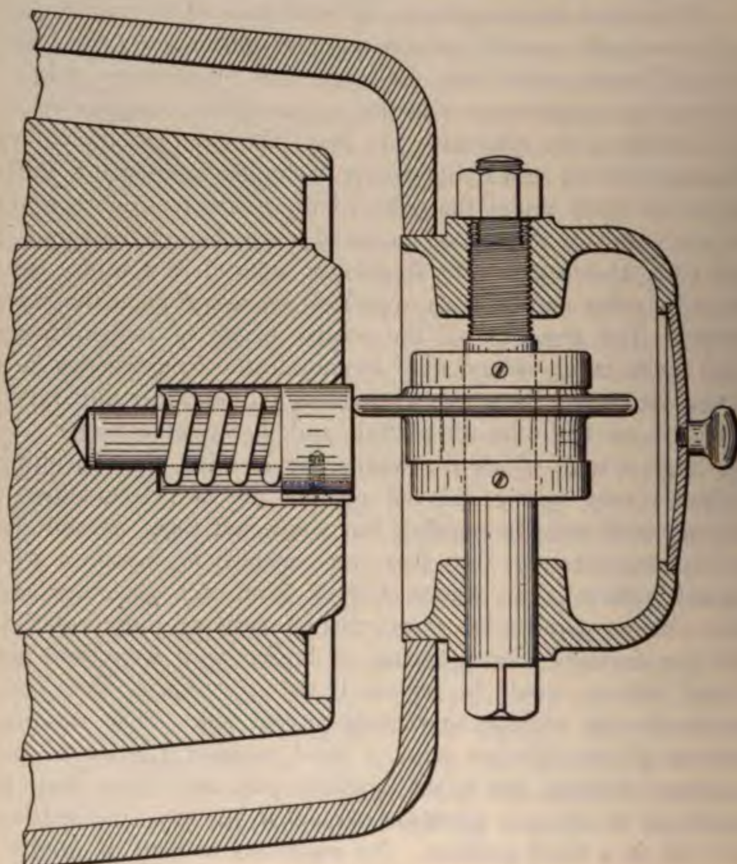


FIG. 2—SHAFT OSCILLATOR

has very many characteristics in its favor, but for larger sets, the combination of a synchronous machine and a direct-current machine has a great many points in its favor in spite of the necessary auxiliaries. It is possible with such a set to convert either from alternating into direct current or *vice versa*,

and, very frequently, the very reason for having a motor-generator set is to tide over a growing alternating and direct-current system. Figure 3 illustrates a 500-kilowatt motor-generator capable of operating from 4600 volts alternating current and delivering from 230 to 300 volts direct current. As indicated in the earlier part of the paper, for 60-cycle transformation, a motor-generator up to voltages of 13,000 to 15,000 will cost very little more than a rotary with its necessary transformers, besides

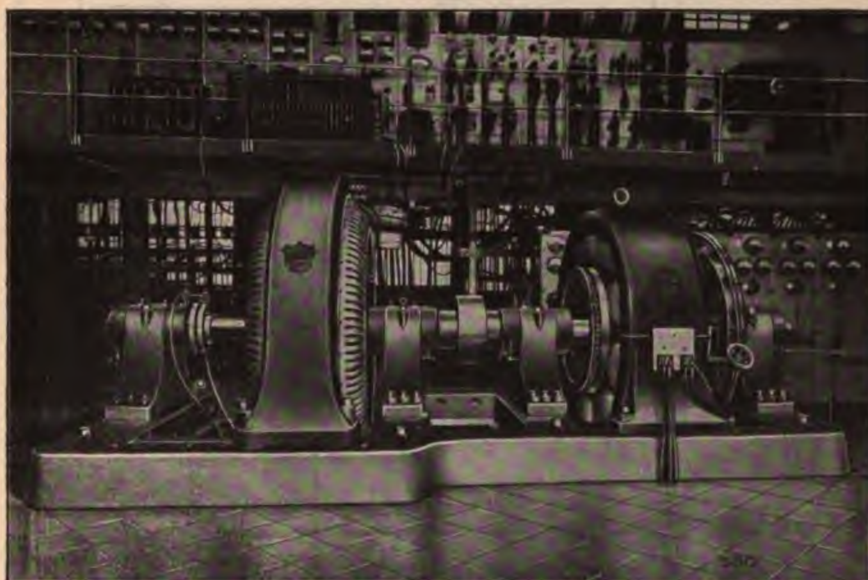


FIG. 3

having the great advantage of being operated with one side entirely independent of the other, so far as voltage is concerned.

Starting Motor-Generator Sets

The starting of a motor-generator is accomplished more simply, as in the case of a rotary, by starting the direct-current machine as a motor. Figure 4 is a wiring diagram for such a case. When it is not possible to start from the direct-current end, synchronous motors are often started by means of choke coils or low-voltage taps on the transformers, just like the rotaries.

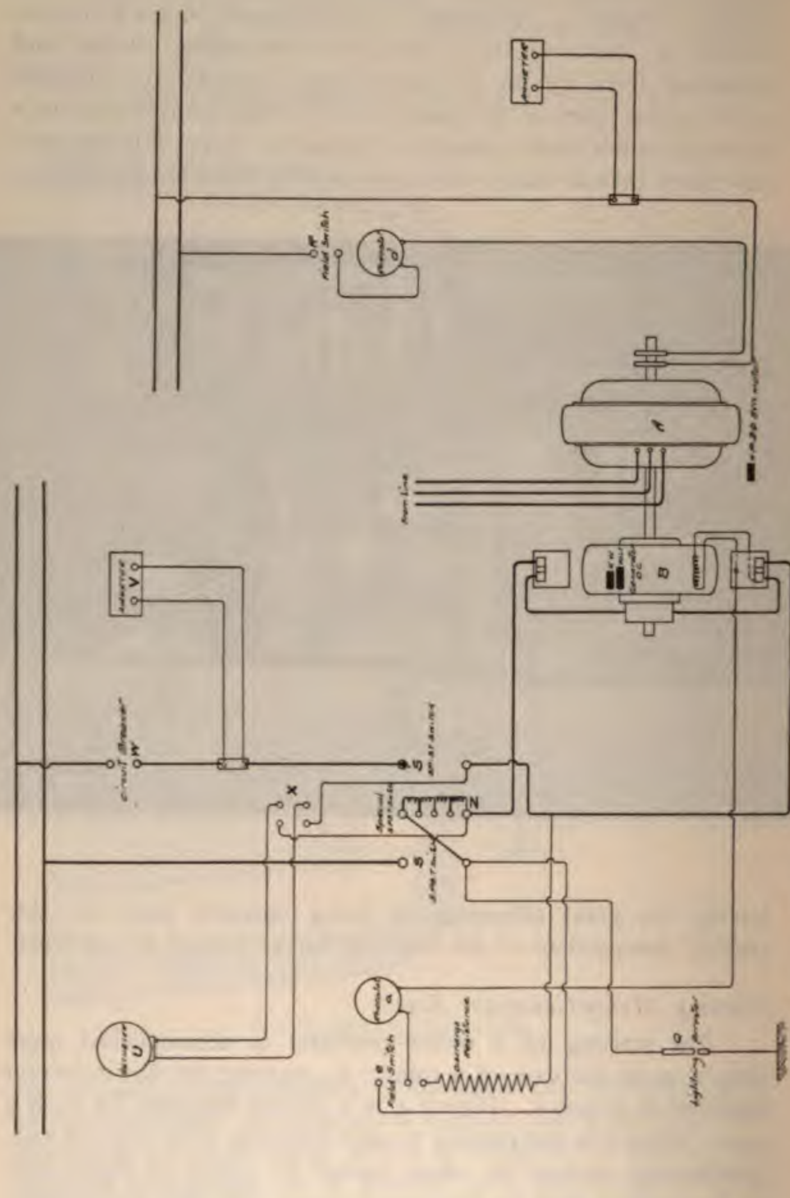


FIG. 4—WIRING DIAGRAM—STARTING APPARATUS, THREE-PHASE MOTOR-GENERATOR

The currents here also may be extremely large, and the writer is aware of more than one plant that has been shut down by starting in this manner, the synchronous motor drawing so large a power from the line. An induction motor starter may also be used. A very pretty scheme has been adopted in a number

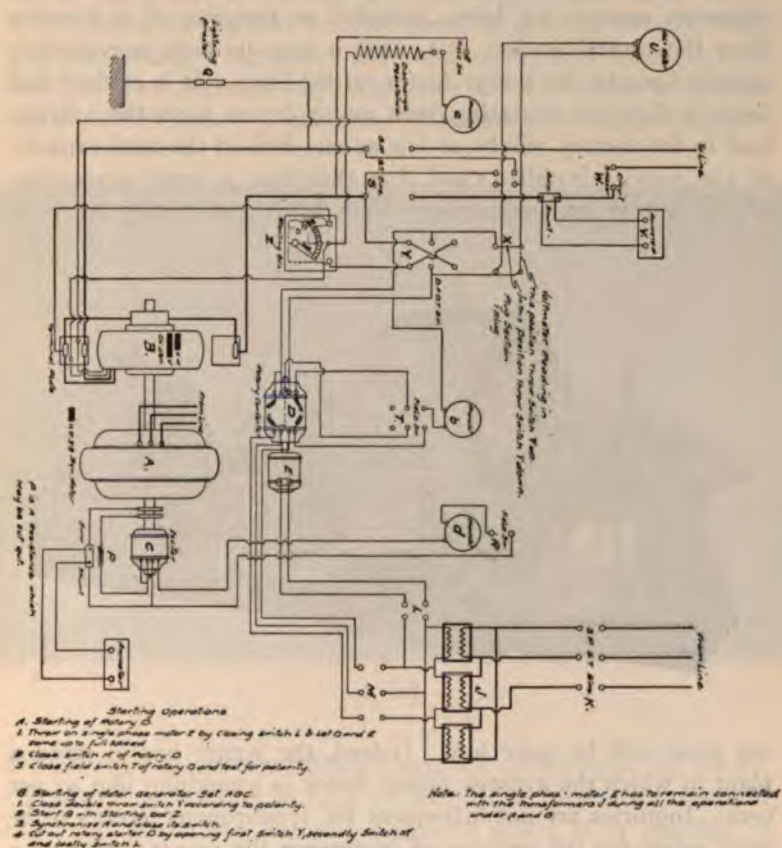


FIG. 5—WIRING DIAGRAM—STARTING APPARATUS, THREE-PHASE MOTOR-GENERATORS

of cases. A small single-phase motor is used to start a small rotary converter, and the large generator is started from the direct-current side of the rotary, the rotor being steadied by the single-phase motor that was coupled to it, thus giving it a considerable overload capacity. Figure 5 shows the starting dia-

gram for this particular case, and Figure 6 shows the small starting set referred to.

Operation

From the standpoint of operation, the synchronous motor has one very great point in its favor, especially from the fact that induction motors are being installed in factories at a distance from the central station, *i. e.,* that it may be very conveniently used to keep up the power factor on the line. It is evident that since in factories operating with motor-driven tools the average load in the factory will be as low as one-fifth of the total capacity of the motors installed, and that therefore a large percentage of the motors are operating at light loads, the power factor of

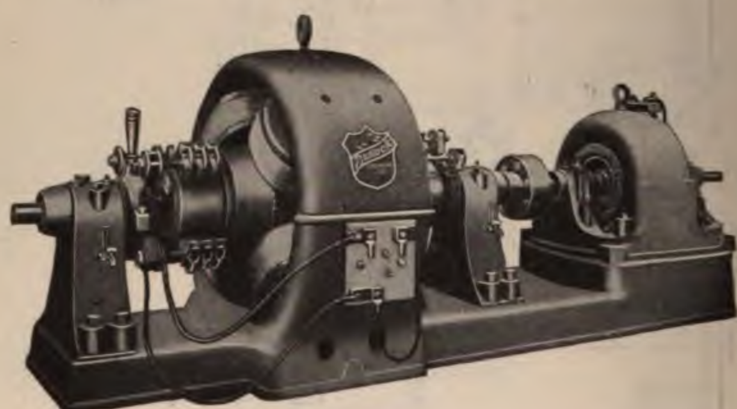


FIG. 6

the plant will be quite low. Indeed, the writer has in mind a plant in which the average power factor is something like 40 per cent. Inquiries are not infrequent for synchronous motors to be used solely for the purpose of increasing the power factor of a system. It is well to keep this point in mind, in the selection of a unit, to provide a balance between the alternating and direct-current systems of a station. However, the point must not be lost sight of that if a synchronous motor is to develop a certain output in brake horse-power and to supply a corrective current for increasing the power factor, it must be considerably larger than if it were to deliver its load at or near unity power factor.

Frequency Changers

The fact that power must not only be distributed in large towns but often sent to its environs, makes it necessary to employ frequency changers. Sufficient thought is often not given to the correct choice of a frequency changer. It must be remembered, for instance, that the energy is to be converted from 25 cycles to 60 cycles, the highest possible speed to get this exactly being 300 revolutions. Naturally, for small units, this speed is such that the price becomes high, therefore a compromise is effected and an odd frequency is adopted; for instance, frequency changers

Fig. 7

are built of 100 and 200-kilowatt capacity, operating at 750 r.p.m., transforming from 25 to 62.5 cycles. Now, in starting a set of this kind, there are but two positions where it is possible to operate both the 25-cycle and the 62.5-cycle ends in parallel with other units, and it therefore requires some manipulation to get the machines into one or the other of these positions when starting up. In operating a frequency changer in parallel with either another frequency changer or with a generator on the high-cycle end, there is but one way to throw the high-cycle end in parallel with the other unit. If the other unit happens to be of the same capacity and characteristics,

the excitation of the generator end of the frequency changer must be the same as that of the unit with which it is to be brought in parallel, because after it is thrown in

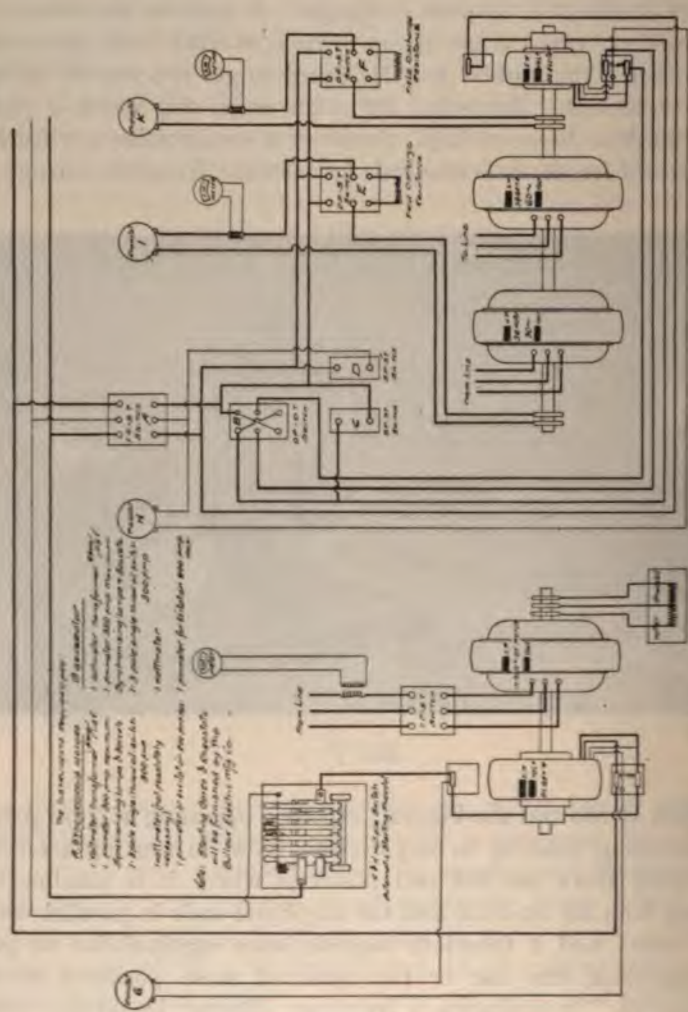


Fig. 8—Diagram of Connections for Frequency Changers

parallel, change in excitation on neither the motor nor the generator will produce anything but an interchange of wattless currents between the sets. A very interesting installation of

frequency changers exists in Montreal, where the power from Shawinigan Falls, some 85 miles distant, is converted from 30

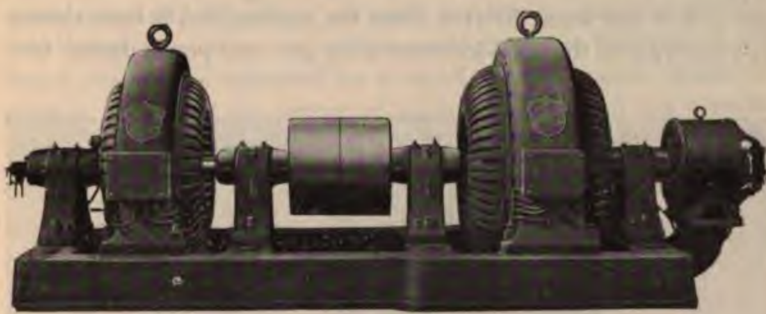


FIG. 9

to 60 cycles. Five units of 800 kilowatts at 75 per cent power factor have been successfully operating for several years. Fig-

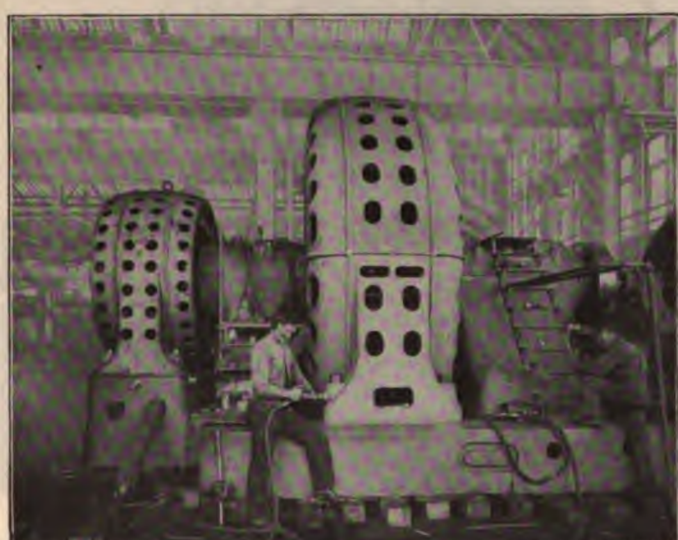


FIG. 10

ure 7 shows a part of this station. In the foreground will be seen a small induction motor-generator set, which is used for

starting each of these five frequency changers. The diagram of connections for this purpose is shown in Figure 8. Figure 9 illustrates a small 100-kilowatt set operating from the Shawinigan power line some distance from the station, and is here shown as a contrast to the 4000-kilowatt at 75 per cent power factor fre-

FIG. 11

quency changer recently installed and tested; the latter set having a combined capacity of 13,000 kilowatts at 100 per cent power factor for five hours. Figure 10 is an illustration of the synchronous motor end of this large outfit, and shows also the

induction motor directly coupled to the shaft, this motor being capable of developing 1600 kilowatts synchronous torque, which starts the large set up in an incredibly short time. The water rheostat, Figure 11, is used for the purpose of starting this induction motor. As will be noted from the illustration, the water rheostat is operated by a small electric motor, which in turn is controlled by means of push buttons from the switchboard, so that the whole set is readily started directly from the switchboard.

DISCUSSION

THE PRESIDENT: Is there any discussion on the paper that has just been presented to the meeting?

MR. CLARENCE RENSHAW (Pittsburg, Pa.): I should like to differ a little with Mr. Bogen in regard to the desirability of 60-cycle rotary converters for direct-current voltages of 250 and 500. It is true that it is difficult to design machines of this kind, but it is undoubtedly also true that by using the proper skill rotary converters for this frequency can be designed that will operate entirely satisfactorily for direct-current voltages of 500, or even 600.

There is another point in connection with this matter of motor-generators which Mr. Bogen has not brought out. That is the liability of a sychronous machine under varying load to affect the voltage of the system by means of changes in its power factor. If a rotary converter is operating with a variable load, its field current can be so adjusted that when running at light loads the rotary converter will cause a lagging current on the line and when running at heavy loads a leading current on the line. The effect of the lagging current will then be to lower the voltage of the system and that of the leading current will be to raise the voltage of the system. This action can be utilized to secure good regulation on lines where with a motor-generator set the regulation would be poor. I have in mind a certain 60-cycle plant in which lighting and railway service are operated from the same machines and the same 'bus-bars. It is a plant of moderate size, so the railway load is extremely fluctuating. If motor-generator sets, particularly induction-motor-generator sets, were used for operating the railway load, when a heavy load was momentarily called for by the cars the voltage on the entire system would feel the pull, and when the cars "let go," the voltage of the system would suddenly rise. With rotary converters, however,

the fact that when the load is light the current taken by the converter is lagging, and when the load is heavy the machine takes a leading current, tends to counteract this effect. When the cars take a heavy current the leading current in the rotary converter tends to counteract the drop on the system that would otherwise occur. Again, when the car lets go, the current in the rotary converters becomes a lagging one, which tends to reduce the voltage of the system and thus prevent the sudden jump in voltage that would otherwise occur. It is true that if a motor-generator set driven by a synchronous motor were used the same action could be had; but if a synchronous machine is used at all it is naturally desirable to keep the outfit as simple as possible, and a single machine, such as a rotary converter, is infinitely more simple than a synchronous-motor-generator set, and if properly designed is equally satisfactory and reliable.

Mr. Alex Dow (Detroit, Mich.): I think that in this question of motor-generators as against rotaries the distinction is not always made, as it should be, between the conditions of railway service and those of lighting service. I think, also, that exception must be taken to the last statement of the preceding speaker if that statement was intended to cover lighting service. In railway service it is possible to compound the rotary with the line to get the excellent result pointed out, namely, a minimum of disturbance to the system by the varying loads of the railway service. The line is there, anyhow; and while it is sometimes necessary to add external inductance, as a rule the transmission line can be made of itself sufficiently inductive to give the necessary compensation. In that case your circuit reduces itself to a set of transformers (or a single three-phase transformer) and a rotary. There are conditions of lighting service, however, in which the variations of direct-current voltage that are normal in railway work can not be tolerated. The transformers for the rotary must be supplemented by regulating devices to give the necessary range of voltage control. The result of this in some recent stations in which rotaries are employed in direct-current lighting work is that the rotary equipment is not only more complicated than a motor-generator set, but is absolutely more expensive. In other words, if a long range of regulation is required the cost of your regulating transformer and your step-down transformers for the rotary, plus their foundations and

auxiliaries, plus the usual runaway device on the rotary, and a few other extra fixings which that touchy piece of apparatus requires, is equal to or greater than the cost of a motor-generator set. If our technical advisers and our speakers at these meetings, and those who write for us in the technical press, would differentiate distinctly between the two conditions I have indicated, they would find at one end, where exact regulation is required, as for lighting service, or where the range of regulation is long, that the motor-generator under our American conditions has very many advantages; while, on the other hand, in railway service the rotary, even if it be a 60-cycle rotary, justifies its existence completely and leaves no choice. Given the one set of conditions, you will take the rotary converter; and under another set of conditions you will take the motor-generator. Under intermediate conditions it may be a difficult matter to decide and it may become a matter of individual preference; but at these two ends—lighting service, with exact regulation or with a considerable range of regulation on one hand, and railway service, particularly interurban railway service, with rapidly varying loads on the other hand—there is no choice whatever. Both from financial considerations and from consideration of the reliability of service the one condition predicates the motor-generator and the other condition predicates the rotary converter.

MR. H. J. GILLE (St. Paul, Minn.): There is one point in regard to motor-generators and rotary converters that Mr. Bogen has not touched on at all, a point that I think is very important, and that is the advantages and disadvantages of both as to reliability of service in case of lightning troubles on transmission lines. It seems to me that many members of this association are interested in the question of continuous service on transmission lines and protection from lightning troubles.

THE PRESIDENT: A request has been made that before proceeding with the next paper there should be some discussion on the report of the committee on progress, which was submitted this morning.

DISCUSSION OF REPORT ON PROGRESS

MR. WILLIAMS: Mr. President and gentlemen—It seemed to some of us that this excellent report of the committee on progress should not go into the minutes of the meeting without some

discussion. Mr. Martin's report last year did go into the minutes without discussion, and I think a great deal of valuable information was thereby lost. With some others, I asked the president if a few minutes could not be devoted to this report.

I should like to draw your attention to Mr. Martin's reference (page 20) to the work of Mr. Alex Dow at Detroit in the use of the exhaust steam for the purpose of evaporating brine and thereby deriving salt. I think we should ask Mr. Dow to say something on that subject.

Permit me to draw your attention to some statements on page 26, the results of calculations by Mr. Pearce, of Manchester, England—an engineer of wide note in England, who has made a careful study of the relative costs of different artificial illuminants—where he reaches the conclusion that the cost per mean candle-foot per hour for arc lamps is 0.66, whereas for intensified gas lamps—the form of illumination taken in comparison—the cost rises to 0.79 cent. The table on page 27 (in the final results in which perhaps we can not all concur, due possibly to differences in cost in England and here) is very interesting, and I think would justify careful consideration on the part of our members.

I think also that the references of Mr. Martin to the use of the mercury vapor lamps are very valuable. He states truly that the lamp is used to a very large extent for the commercial lighting of one of the largest buildings in New York. The men who work under the light in that building, and those who work under it in other buildings, say that after taking two or three days to become acclimated, as it were, they would not willingly work under any other form of artificial light. Then, under the head of other illuminants, on page 31, Mr. Martin refers to the Nernst lamp development. I for one should like to hear a great deal more about what is being done by the central-station managers in the development of the Nernst lamp and the results they are getting from its use. Reference is made to the use of the Nernst lamp at Pittsburg, where they have 600 kilowatts installed, and I have in mind a smaller installation in which something more than 100 kilowatts of the lamps have been installed; but the use of the Nernst lamp in place of the cheaper illuminants, such as gas, is still in its infancy, and I think it forms an interesting subject for discussion.

Another division of Mr. Martin's paper relates to electric heating. We are to have a paper on that subject and therefore I pass it over, but I should like to ask if Mr. Martin knows the present cost of the osmium lamps. He makes the interesting statement in the final sentence on the subject of this lamp that former difficulties of a 110-volt lamp of long life have now been overcome. This lamp burns at something less than two watts per candle and has been known to have an efficient life of 2000 lamp-hours. I would ask Mr. Martin the price at which these lamps may now be obtained in this country, and whether or not he has any information as to the prospect of obtaining them in large quantities.

Mr. Martin finally speaks of electric power for refrigeration. Let me remind you that refrigeration is largely a summer load, in the nature of the service, and it is a kind of service that can be excluded from the peak hours of the four heavy months of the year. It is a very important subject for the central-station manager in the development of his power installations. Mr. Martin quotes Mr. J. C. Chamberlain—an expert who has given a great deal of attention to the subject of electric refrigeration—in the statement that where electric current can be obtained at less than five cents per kilowatt-hour electric refrigeration is cheaper than ice.

Looking over the report, if anything at all has been omitted by Mr. Martin—and I hesitate to say that anything has been omitted—I would say that perhaps sufficient emphasis has not been given to the recent development of electric signs all over the country. The development of these electric signs is a sign of the times. Electric light in one form or another is recognized by the advertising experts as one of the great mediums for advertising, so much so that it ranks to-day with advertising in the newspapers and the magazines. The companies that have not attempted to develop the sign business along such lines as those followed in Denver and Chicago are losing opportunity for large revenue.

Mr. W. C. L. Eglin (Philadelphia): I think that this report of progress, made by Mr. Martin, was abstracted too briefly. In reading over the paper I find that so far as lighting is concerned nearly all the points have been touched. I should like to ask, in reference to the Cooper Hewitt lamp, how the candle-

power of the lamp is determined and what is being done toward making a more direct comparison between this lamp and the arc lamp; and particularly where Mr. Martin refers to a large newspaper office. Mr. Martin takes up the lighting, but pays little attention to the motor side of this installation. If there were any criticism to be made, it would be with reference to the omission of data relating to motor control, and especially to such fluctuating control as is found in the newspaper office. I feel, however, that the association is to be congratulated on having such a valuable résumé of the work in which we are all interested.

Mr. Dow: I want to know from Mr. Martin all the things the other gentlemen want to know. Referring to page 20 of the report, with reference to our salt work, I will say that the salt work is not yet going. The reason thereof is not electrical nor mechanical, but purely commercial. The Detroit plant, which has been in operation since last August, is so arranged that we may run non-condensing and that we may deliver the exhaust steam to a salt block; but in the present peculiar condition of the salt market we have found a sufficient reason for stopping the drilling of more salt wells and postponing the installation of evaporating machinery.

That, as is mentioned by Mr. Martin on page 21, there is a possible profit in a combination of industrial processes with the electric-light business, is perfectly certain. There are several electro-chemical processes that are not of necessity continuous processes. When we think of electro-chemical processes we almost invariably associate those processes mentally with the continuous 24-hour-a-day operations at Niagara Falls, Sault Ste. Marie, and in similar locations. There are, however, a number of electro-chemical and electro-metallurgical processes that are not necessarily continuous, and can therefore be run profitably and economically at hours that are not peak-load hours; some of them—let me intimate a possibility—even of such a character that they may be made to assist at peak hours. Did you ever consider that the storage battery is merely an electro-chemical process, reversible with fairly high efficiency, and that there may be other processes of similar character that are partly reversible and may be made (in a pinch) to kick back on the station and help on the peak loads?

Other features of the Detroit work, which Mr. Martin out-

lines on page 21, are possibly of more general interest. He refers to the large new generating Delray plant 3000-kilowatt turbo-generators. This plant was designed as a turbine plant, and possibly shows the turbine under more favorable conditions than most turbine plants do. It is not, however, anything extraordinary. His next item of reference is the generation and transmission of electrical energy at 4600 volts, 3-phase, 60 cycles, instead of the more familiar 25 cycles usually employed for transmission to direct-current substations. This requires some explanation. The decision to use 4600 volts was taken because that seemed to be a good compromise voltage for such an area as we proposed to cover by direct transmission. For that area 2200 volts was too low; and 6600 volts is unmanageable when you try to use individual transformers. Moreover, 6600 volts is so high that the municipal regulations in Detroit are contrary to its use on overhead wires, while 4400 volts, plus the necessary drop in transmission, is permissible. It is a little sloppy, but not so much so as to prevent its being handled "alive" on well-constructed lines by careful men. For distribution through outlying residence districts, which will take possibly 10 to 15 per cent of our total output, we have thought it best to adhere to 2200 volts. We have also thought it best to retain our isolating transformers between the 4400-volt tie-line system and the 2200-volt lines, instead of using a "four-wire" or compensator connection. We learned through experience that if the 2200-volt system going through the residence streets filled with shade trees, and going into the corners and back alleys, were connected direct to the 4400-volt system, with 9000 to 12,000 kilowatts of dynamo capacity on the 'bus-bars, we were liable to have some complicated situations in stormy weather.

In the large motors that we have installed in our new substations, and to some extent on customers' premises—motors of 150 horse-power and upward—the direct line pressure of 4400 volts is entirely satisfactory. I refer, of course, to the motors with the stationary armature winding and the revolving field or rotor.

As to the transforming of alternating current to direct current by motor-generator sets. In my previous remarks at this session I pointed out our reason for adopting these motor-generator sets instead of rotaries. We find our 1000-kilowatt motor-

generator units very reliable, and also find them to be cheap. When you get to such large sizes, if you include the cost of building and cost of regulating apparatus, foundations, auxiliaries, *et cætera*, a 1000-kilowatt motor-generator set is not more expensive than the rotary converter with its transformers and regulating devices and auxiliaries of the same capacity.

As to the use of steam engines at some substations to supply steam heat, besides helping out the electric system. At present we receive from one station, essentially a steam-heating station operated by an independent company, continuously during business hours of the winter months 225 kilowatts, with 450 kilowatts on the peak. We buy this current. In another station we sell exhaust steam from what will be a total installation of 1300 kilowatts of engines to another steam-heating company, which distributes it in the residence district. We are paid proportionately to the meter readings of that company—it sells entirely by meter—and the company pays us a certain amount per 1000 cubic feet of condensation shown by the meter readings. In a third station, which is now being built, the steam-heating company will install two direct-current turbines, and will sell us current during peak-load hours. These turbines are to be of the new mono-polar type; and I presume that a year from now there will be an interesting report to make concerning their operation. They will deliver direct current to the Edison three-wire system. The electric investment made by the steam-heating company is about $46 per kilowatt. The peculiar point of the situation is that the boilers installed for the direct supply of steam have their period of lightest load during the peak load of the electric lighting in the business district. The peak load of the steam-heating system is strongly marked; in the residence districts it is from a quarter before to a quarter after seven in the morning, at the time when people are rising and turning on the heat to warm their apartments. The peak is very sharp at that time. In the business district the peak comes on somewhat later, due likewise to the morning heating up of the premises. In the afternoon, along toward dusk, when business houses are getting ready to close, less heat is required, and the boilers will be available to run the turbines, which will be run with partial vacuum. The conditions are such that to install condensing apparatus for the high vacuum generally called for by the turbine engi-

neers would not be profitable; but low vacuum can be profitably obtained.

The total investment in steam-heating mains in Detroit at the present time, including the plant, still incomplete, is close to a half-million dollars and will go somewhat above that when the work is done. I can not say that it is yet demonstrated to be a financial success. The preliminary figures show that in a town of our size steam heating in conjunction with electric lighting should pay. We feel that the direct supply of steam heat down-town will enable us to get business now done by isolated plants. There are fewer isolated plants in Detroit than in any city of its size in this country. We long ago adopted such a system of dealing with these plants that we stopped their increase, and they are now decreasing. We believe the last of them will come into the fold when their owners can get steam as well as light from a central company.

MR. SAMUEL SCOVIL (Cleveland, Ohio): What area does the plant cover?

MR. DOW: At the present time the residence-heating plant extends about a mile by a half-mile. The down-town heating plant already in service covers an area of about a half-mile square. The other, which is coming into service, will cover a similar area.

There is no correspondence between the demand for steam heating and the demand for electricity. Once in a while you find such a case, but it is apt to be a factory using a large amount of power relatively to the cubic contents of the building, where the exhaust-steam and electricity demands will match. In a residence district it requires four residences to take electric light, to heat one with steam; and unless you can find some external power business you will decide at once that you must cover a great deal larger area with the electric mains than with the steam mains. We have in a way obtained that result by reversing our motor-generators and tie lines and putting power on to the alternating-current power system. We are now installing one of our old alternating-current sets in our residence-district station to give alternating current directly to the tie lines.

The last feature mentioned by Mr. Martin is an extensive power service and the distribution of power current to factories by means of 4600-volt, 3-phase circuits. That power service is

extensive in area, but thus far has not obtained the amount of business that would warrant it in being described as an extensive system. Still, the contracts are coming in; and we are satisfied that we shall get the business. I have to-day received advice of the signing of one contract for 24-hour supply to a large manufacturing institution, which will mean a minimum bill of $27,000 per annum. The price is low. If anyone wants to buy current—4600-volt, 3-phase current, delivered at our 'bus-bars, regulated to between 4400 and 4700 volts—we are perfectly willing to sell it at the 'bus-bars at a low price per kilowatt-hour for 24-hour service, or at a proportionately low price for shorter-hour service. We have a railway contract under a differential rate that brings in a corresponding price. The load factor of the railway load is good—about 18 hours a day. I may say, to throw further light on the price question, that our present rate for secondary alternating-current supply for 10 hours' service per day, 3000 hours a year, gets down to 2.5 cents per kilowatt-hour under certain conditions of minimum investment. For shorter-hour service or greater investment the rates must be proportionally higher, on account of increased fixed charges.

Some of the things Mr. Martin mentions we are now sure about. We know enough about them to be certain that our plan is correct. As to others, we feel we are all right, but shall be more positive about them later. If any of you care to study the matter more closely, either by a visit to Detroit or by asking some definite questions, I shall be willing to answer more precisely. Our theory is that one frequency should be enough; that the alternating-current service is the service to push; that the cost of transforming to direct current, while unavoidable under present conditions, is one we should not seek to increase by the offer of direct-current service when alternating-current service will be satisfactory; that the 4400-volt motor in large units is entirely practicable; and that the alternating-current motor in small units taking power service from lighting circuits is also entirely practicable.

Since our original plans were laid out, involving the covering of an area of 30 square miles, there has come to us the necessity of building three different transmission lines, one of which, 16 miles in length, is already in operation. Of the other two, one is under contract and the other is at the present time being

considered, and whether it is to be built this year or next will depend upon negotiations to be concluded within a month. One of these lines will ultimately deliver about 3000 kilowatts and will ultimately extend 40 miles. For such lines 4400 volts is too low to be profitable, therefore we shall have within a few months a considerable transmission system of 22,000 volts, partly underground and partly overhead; the voltage being limited to 22,000 volts because that was the limit at which the manufacturers of cable would guarantee the insulation. The fact that we shall now be users of 22,000-volt apparatus does not affect our original plan. It comes from the necessity of covering not merely an urban area, but pretty much a whole county.

THE PRESIDENT: If there is no further discussion on Mr. Martin's report, we will take up the paper on *The Organization of Working Forces in Large Power-Houses,* by Mr. W. P. Hancock, of Boston.

The following is the paper presented by Mr. Hancock:

THE ORGANIZATION OF WORKING FORCES IN LARGE POWER-HOUSES

As this paper will deal with the matter of organization of working forces in large power-houses, we will assume that we have approved and economical apparatus, on both the steam and electrical ends of the system; this being true, it would seem that if we added an organization to operate such a system so that the best results would be obtained from the complete plant, we should find our generating cost per kilowatt-hour satisfactory.

As there are companies whose generating accounts are not identical with ours in Boston, with reference to the charges placed under the head of "Generating," I will mention here that I shall deal with a department that contemplates the expense of operation, also the repairs and renewals of all steam and electrical machinery and apparatus, including storage batteries necessary to generate and deliver to the 'busses and switchboards the output of the generating system, the necessary distribution from substations, and including, of course, all labor, from the head of department to the errand boy on the office end, from the chief engineer to the coal passers on the steam end, from the chief operator to the cleaners on the electrical end, also the battery engineer, his assistants and workmen; and when the total charges are made at the end of the month, and are divided by the kilowatts generated, we shall have the legitimate generating cost per kilowatt, so far as an organization for that purpose is concerned. There may be other charges made against the department, but they are not made by reason of being directly connected with that portion of the total system. It may be well to say at this time that the Boston Edison generating department organization is made up as shown on diagram on page 117.

Having seen what the organization seems like on paper, we will follow down the line, beginning with the

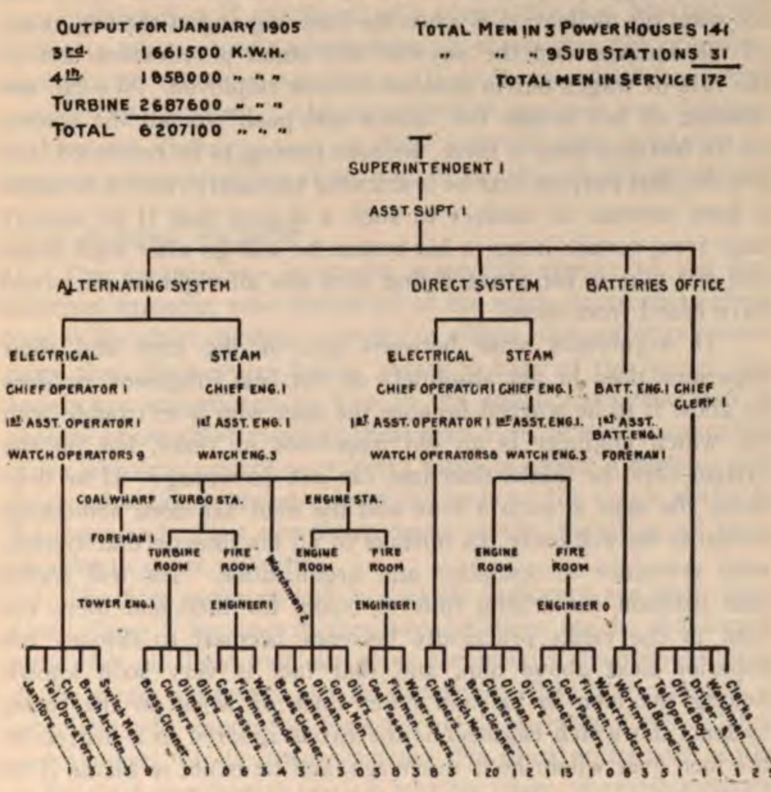
Steam Division

The chief engineer of the steam system is, of course, totally responsible to the head of department, or his representative, for

the good and economical operation of that system; and in order to be able to assume that responsibility in a manner favorable to the company's interest, and with success for himself, he must have among his various accomplishments a few which I will mention, and which I claim are extremely important.

We will assume that he came to us with the necessary

ORGANIZATION OF GENERATING SYSTEM AT THE THIRD, FOURTH AND TURBINE STATIONS OF THE EDISON ELECTRIC ILLUMINATING CO. OF BOSTON



license, that he has had a good and varied experience with steam engines and auxiliaries and is a first-class mechanic. Perhaps we know him by reason of his having been employed on a nearby system for some time, and, if this be the case, we have had the opportunity to see what kind of an organizer he is, what his judgment is in the hiring of men, whether he has the ability to

maintain discipline among his men and takes an interest in knowing whether or not it is maintained, and whether he plans the work of his system and passes his orders to his first assistant, to be passed by him down the line, in such a way as to avoid the bad complications caused by conflicting orders given by himself and his first assistant to a watch engineer, perhaps to others of his organization. We can see whether he has favorites among his men by reason of earlier acquaintance with them; if he has and it is apparent, we know there is trouble ahead. We can see what his inclination is when the load is going at the beginning of the summer and the pay-roll will stand a reduction, not in the rate of wages but in number of men employed. We can see whether or not he has the "hustle and push" to put the system on its feet and keep it there, without having to be reminded that it is for that purpose that he is drawing his salary; also if he takes a keen interest in matters to such a degree that if he doesn't hear from certain items in his system he will go after such items and not take it for granted that they are all right or he would have heard from them.

If arguments arise between any of the men and their superiors, does he act absolutely on his best judgment, or does he allow it to be warped because the man who is in trouble with his watch engineer is an old man—not in years, but on the system—and he thinks that man can not do wrong? If he does favor the man at such a time and the man has done something irregular he will make the mistake of all his time on that system, with reference to discipline and organization. He will regret that decision for a long time to come, for then and there the man in the ranks practically becomes licensed to disobey his superior next above him, and that fact is very soon known among the men in his and other lines of work on the steam system; the watch engineer is thereafter ignored to a degree by the men over whom he is in charge, and he is not to blame if he leaves his position, rather than lose the reputation that he may have earned by his ability to work his watch successfully and to the interest of his employer.

It is the business, and a valuable part of the business, of the chief engineer to administer in such cases in a manner that is just to all concerned, from the interests of his employer down to the interest of the man who was disobedient, and also in such

a manner as will preserve the dignity of his position and, at the same time, by reason of just decisions, retain the respect of his total organization. He should administer justice without fear or favor, and while the way may be rough for a while it will assuredly smooth itself in due season; and what could be more satisfactory to the head of the steam division than the positive assurance that his assistants and men were working in harmony for their own interest, for his interest and for the interest of their employers?

I claim that if the head of a steam division has not the ability to take care of these matters on these lines, the organization will be far from satisfactory from the standpoint of good service and economy. Almost any chief engineer can continue to hire and discharge men at short intervals and claim that as his only alternative; but if he does, it is a loss to his employers.

First Assistant Engineer

The engine-room is in the immediate charge of the first assistant engineer, who directs all of the work from orders given him by the chief engineer. As he, of course, can not be on watch more than the regular hours, unless in case of emergency, the orders are transmitted by him to the watch engineers, and in absence of the chief engineer these men have, in their consecutive order, absolute control over every piece of steam apparatus and the appurtenances thereto, from the ends of the crank shafts to the outer end of the circulating water intake, including all labor incident to steam operation.

The first assistant and his watch engineers are busy men. I say "busy," because if they are not they are in the wrong place, for on these men we place secondarily the responsibility of the steam apparatus and its operation. The first assistant is especially held responsible for economy of operation, both in labor and material, of the steam system. He must notice and report to his chief any repairs needed, whether large or small, whether it be the keying of cranks or wrists, opening of cylinders, adjustment of pistons, packing leaky valves or glands, leaky steam lines, whether they be mains or drips; must look after the water lines; the proper working of the air and circulating pumps; the condensers and canals; the undue consumption of cylinder or engine oil and waste; the oil system, and also, incidentally

(although he has a watch engineer in charge under him), must notice and criticize the number of boilers in line to operate the number of engines in service when using certain grades of fuel; in fact, it is required that he be a man who can think quickly and not take too much time to execute. He must be thoroughly conversant with every line of steam and water pipe, every valve and its use, and what will probably occur if misused. It is his duty to instruct all of the men under his charge in the working of every piece of apparatus in the steam system, and if he is found to have inclination to dispense only such information as is absolutely necessary for his men to operate with, with an idea that he knows the system as no other man does, and he thereby hopes to insure his position more permanently, he is not the man for the place, because he is working for his own interest especially and incidentally only for that of the company. On the other hand, he should make especial efforts to have every man under him thoroughly conversant with the system; first, because it is for the best interests of his employers; second, because in a way it will lighten his own labors; third, he will receive the credit due from his men, and those men will appreciate his efforts to place them aright in their work; and, last of all, his chief will appreciate the fact that he knows how to work his men and produce results that the company is looking for, and this without discontent in the ranks.

Again, there are cases of emergency when the first assistant is required to work overtime, and so must his watch engineers as well, and their men, and here the treatment of the men should be thought of. If they are working by the hour and are allowed overtime they will probably be satisfied; if they are working by the week and don't get overtime but do get a number of days off with salary each year, they may feel that they are losing something by reason of such emergency. In such an emergency my instructions are to see that the men are well fed and that they are given such reasonable time to recuperate as the load demands on the system will admit; and I may say that with this latter method we have no difficulty.

Watch Engineers

Of the watch engineers we must require as nearly as possible the duties of the first assistant, with the addition that the orders

of the latter, as to work to be done during the hours he is absent, are to be strictly obeyed, and the results must show favorably when he again appears on watch. It is in these cases particularly that good discipline among heads of divisions shows itself prominently, and if it does not exist, the repairs on apparatus will fall behind, and little by little we shall begin to find the system in a bad position and one from which it means hard work and long hours to get back into line.

The Oilers

The oilers come next in line in the engine-room, and on these men we rely to keep the engines in operation after once started and to know absolutely that the large number of oil feeders and grease cups found to-day on reciprocating engines are in proper operation. An oiler must give immediate notice to the watch engineer of any irregularity in the operation of his machine; must see that he is using enough oil, and not more than enough, and when his machine goes off the line must wipe it up and clean it ready for the next run. These men are important in their positions, whether the title implies it or not, for power stations, unlike steamboats, can not afford to shut down to cool hot bearings, nor can we afford to let the customers drift, as the commander might let the ship drift at sea if emergency occurred and weather and sea room were favorable.

I consider an oiler important when the question of hiring men comes up in the fall. I lose no opportunity to take the name and address of all men who have had experience in that line, and find such a list very useful when the fall load begins to appear.

We should, and on our system we do, pay oilers who can oil an engine properly one rate of wages, and that only to such men as are competent to run the pumps when required; and with beginners on the system we practice the method of moving them along and higher in the matter of wages as they grow more proficient in the work, and lose no proper opportunity to show them that proficiency is the one thing most needful, and that such an acquirement, together with a strict observance of orders from their watch engineers, will lead them to acquire the maximum wages paid for that line of labor.

The cleaners come last in the line of engine-room labor, for in the matter of repairs the first assistant and such oilers as

are at his command take care of such repairs as can be properly done in the station, while such repairs as are heavy, or those that require machine work, are done by contract by outside parties, our experience being that this is the least expensive method.

The cleaners should be in evidence in every well-regulated power-house, for the reason that in these days of modern buildings and machinery nothing detracts from the appearance of an engine-room more than filth. In my opinion, when we consider the vast number of customers we serve and the prospective customers who visit our power-houses by virtue of passes given them from our general offices, we can afford to keep our stations clean and add to our reputation in worth more than the cost amounts to, and I think any conservative central-station man will agree with me. More than this, the cleaner is a general-utility man; he is useful at a great many times when another man or two must be had, and in case of emergency we can, under the eye of the watch engineer, have him oil an engine or do other work not properly in his line.

The Boiler-Room

We can now take up the operation of the boiler-room, that portion of the system which can be so handled as to assist greatly in paying dividends, and can also be handled in such a manner as to be largely the means of passing one, especially if the coal supply is uncertain as to quantity and quality, for in this latter case we must necessarily save at every other point in order partially to make good such deficiency. Therefore let us at once have the fire-room in charge of a competent man whose immediate superior is the engineer on watch. We need a man for this place who carries a first-class engineer's license; one who has had experience in the engine-room and thus understands practically how the load rises and falls; one who will keep in touch with the watch engineer and realize that it is absolutely necessary that he do keep in touch with that man and know as far ahead of time as is possible what his future needs will be.

We need in this man ability to supervise repairs of all kinds in the boiler-room, including boilers, pumps, headers, leads, valves, furnace brickwork, grates, and all other items in that part of the system. We want him also to be a man of sterling

worth in the handling and judging of men. We want him to realize that a fireman is a man, and, as such, is entitled to proper treatment at all times. We want him to have ability to judge whether a little encouragement will bring out the best efforts of the man, or whether it is necessary in order to obtain such efforts to place the man strictly on the line and make him understand what results he must obtain if he stays on the pay-roll. We want him to be obedient to his superior and be able when he goes off watch to have his work laid out to cover the time until he again appears; such a man as I describe should receive the same salary as a watch engineer, not because he ranks as high in the line, but because he can earn the money.

The Water Tenders

Next come the water tenders, who are in charge of the fire-room watches when the foreman is off watch and who, in such periods, are immediately responsible to the watch engineers, and have a quota of firemen under their charge, as well as all other men of the fire-room force. The water tender may be apparently perfectly competent to occupy his position by reason of his coming to you with a proper license and a long list of recommendations from former employers, but the question will arise as to whether he will fill his proposed position as follows: Will he pay strict attention to the instructions given him by the foreman of the fire-room, or the watch engineer, if that man be in charge, as to the probable demand for steam; does he watch his boiler feed and regulate his boiler feed-water apparatus so that with a heavy demand he is not caught with water too low, and then when absolutely obliged put in water in larger quantities than usual, causing his firemen to do some very heavy work and probably some uneconomical firing, a few repetitions of which will cause complaint and discontent among his men? And, from the other point, does he pay attention to the decreasing load and work the water up to the proper point, and go along the line and watch the depth of the fires, and instruct his men, as per his instructions from the watch engineer, that the load is "going," and to avail themselves of the opportunity to clean fires, to fire light, or bank, or both? Does he watch the steam leaks within the limits of his portion of the boiler-room, and does he see the small repairs needed and report them to the engineer of

the watch, even though he feels sure that the engineer knows of those matters? And, finally, has he the interests of the company in view? If he does not properly deal with these items he is not the kind of water tender we want, no matter what his ability actually is. It is extremely important that the watch engineer take particular notice of the water tender, not only as to his ability to perform his proper duties, but also as to his inclinations, and report to his superior if the man is delinquent in any way.

The Firemen

The firemen are those of the force whom we must select with care, for the type we need must have had experience, and must have judgment and be reliable. That is to say, we can not afford to have a man with us who is afflicted with pay-day sickness. We want him eight hours a day seven days a week, and I am glad to say we have a large number of this kind who like their positions well enough to work steadily for the periods mentioned above. We want men who will obey the instructions given them by their superiors, and those who are free from connection with any organization that would interfere with men that are getting satisfactory wages and treatment and are contented. We want men who, when occasion requires, will hand-fire 2000 pounds of coal an hour, and do so for several hours, if necessary. We want men who will burn coal, and not simply dispose of it; men who will use judgment in both firing and cleaning fires, and if the plant is using stokers of the type we use on our system, it is of the greatest importance that he should watch the coal as it comes to him and regulate the depth of the feed and the speed of the grate in accordance with both the quality of the fuel and the demand for steam as his best judgment dictates, and act promptly on instructions given.

Firemen are a class of men who must of necessity do very hard work, and they are also a class of men upon whom the power stations are to a large degree dependent for their continuous operation. Both of these facts should be taken into careful consideration, especially as to the treatment of these men, and as to the wages paid them—two items which should be uniform throughout the fire-room; I mean by this, that all first-class licensed firemen should receive the same wages; not because a man comes to you with a license, nor because he claims he is first-

class, but I mean that he should go on the pay-roll at your stated rate for first-class men in his line, and it is for the water tender, or other higher authority, to determine in the first few days whether or not the man can substantiate his claim. If it is found, after due trial, that he can not perform his portion of the work, then he is not entitled to the rate of wages that the others are who can. Shall we then tell him that he must work for less wages? I say no, but rather take him off the pay-roll and tell him, in a proper manner, why he is taken off, and at the same time eliminate any chance for the others to argue on different rates of wages and the comparison of abilities. In other words, I don't want a new man to come on the pay-roll and stay there unless he can handle the work as well and to the same amount as his fellows, and I want but one rate of wages for firemen, and that a fair one, and the man who proposes to earn that rate must be equal in ability to any who are classed under the rate.

As to the treatment of the men as a whole, I have learned by experience that a small amount of favoritism made apparent in the fire-room can and will cause discontent and a tendency to avoid the regular amount of work due to be performed by each man, because an idea is harbored to the effect that the other fellow is having an easier time; as, for instance, a water tender may so conduct his watch as to make the following watch clean fires when his watch should have done it, which entails on the men following a larger amount of work than they should perform, and also causes the latter to use an amount of coal not in proper comparison with the load on the system during the time they are handling the fires. Such matters should result in a hasty but nevertheless thorough investigation, the facts should be gotten at, and those guilty of such practice should receive positive assurance of what would happen if a repetition should occur.

I may add that we try to operate fire-rooms as closely as is possible on this basis, and that we find no trouble in placing first-class help in this line in front of the fires. We have good men go off the pay-roll in the spring, when the load falls off, who leave us with good feeling, and by early autumn we have many of them back again looking for their old jobs, as they know by experience when the load begins to rise and more men are required.

The Coal Passers

Last among the men classed as boiler-room help come the coal passers. On these men we depend not only for handling coal but for the cleanliness of the room, and although it is a hard place to keep clean, it can be done to a degree that is eminently satisfactory to all who enter it. A little spare time on each watch, especially on Sundays and holidays, when the load is below normal, can be used in a manner not to cause reflection as to expense and, at the same time, make even the men who work in the room feel a sense of content, while a like feeling could not obtain in a fire-room which contained the dirt and filth of months of accumulation, with no prospect of its ever becoming any better.

THE ELECTRICAL DIVISION

We can now take up the other half of the system, so to speak, or the electrical portion. This part of the organization is divided into six parts, as the classification page indicates. We depend on this portion of the labor system for many important items of operation, the most important of which are:

First, a uniform pressure at the feeder terminals throughout the entire system.

Second, the proper and economical loading of machinery under the charge of the division; and,

Third, we hold this division responsible for the welfare of all electrical machinery, which must be, so far as possible, always ready for operation.

I may say that all repairs, except minor ones, in the division are done by outside parties. With the modern stations of to-day operating lighting and stationary motors and other low-tension apparatus, at the same time delivering alternating current to substations, there is involved a vast amount of apparatus, due to the fact that we must have as much flexibility as possible. We must also have several ways of attaining the same object, as to the delivery of current, in order to safeguard our customers against interruption of service and, incidentally, preserve our reputation for being a reliable concern to deal with. It follows, then, that we need in a chief operator a man who is absolutely reliable, preferably one who has come up from the ranks and has long since become acquainted with the practical side of operation; one who

realizes and instills into the minds of his assistant and men that one of their most important duties is so to manipulate the load with reference to machines to be operated that all units will be loaded to just as near the most economical operating point as it is possible to have them under the existing conditions. He must at all times be in close touch with the chief engineer and, so far as possible, give the steam division advance notice of his probable demand for steam units, thereby giving everybody a chance to be ready, and giving the customer the opportunity to verify our claim that we are at all times ready to supply current. Above all other things, he must have and use good judgment in the selection of his men and the treatment of them, and must conduct his division in a manner that will not only produce satisfactory service, but will be conducive to contentment among his men and will secure for himself their confidence and respect; which once secured and properly held will be a large factor in maintaining what is as nearly as possible ideal operation.

He should always follow the system of hiring new men at the lower end of the line, and moving those who have acquired a degree of proficiency along to a proper position in accordance with such proficiency, thereby giving them the encouragement of understanding that the greater their proficiency the more valuable their services will become to the company, up to a certain limit in that line of work.

Assistant Operator

The assistant to the chief operator must be a man who can assist his superior, and to that end he must be thoroughly familiar with all of the electrical apparatus in the division. He must be able to occupy the position of the chief operator when necessary; in fact, he must be a first-class understudy, and must realize the fact, too, or he will lose to some degree the sense of his responsibility. He should circulate among the substations and correct and report any irregularity noticed in machines or operators; in fact, he should keep his superior constantly in touch with such details as do not come immediately under the notice of the chief operator, and in cases of emergency should come at once to the station and be ready to assist if needed.

The assistant should also be extremely careful about the placing of his orders with the men, and in matters outside of

absolute routine place no orders without the consent of his superior; many mistakes are avoided if every one concerned is conversant with what is to be done, and with our means of communication in these days, not much time need be lost in giving notice.

Watch Operator

The heads of watches should be, and necessarily are, men who have come up the line and who understand all the electrical combinations that can be made with machines, switches and lines throughout the system; if they are not, they should not occupy that position, nor should they in any case until we know by actual experience that they have the ability described above.

To these men we accord the highest wages paid in the division, with the exception of those of the chief operator and his assistant, and we make them uniform in all power stations of the system. By this method of making men fit the position before they occupy it, we secure the ability we desire, and after it has been proven beyond doubt by a previous practical experience. It is, in my opinion, a serious mistake to class men alike for the sole reason that they have worked practically side by side on the system for a period of time. I say, pay the man in accordance with what he can deliver to you in brains or manual labor equivalent. I admit that the man who can not deliver the first-named portion of a working man's capital, and won't deliver the last item, may conclude to get off the pay-roll and identify himself with some organization or other which may demand that all of its members receive the same wages. If he does this, it is his affair; but we can not afford to pay the same price for ignorance and neglect that we can for ability, aided by push and a desire for further knowledge. In making this statement I do not mean to cast any reflection on a man who may have less ability than others, but instead to speak from a purely business point of view, and I repeat, that the chief operator when hiring men should be particular to move along the best ones, and be still more particular when he takes in his green workmen to observe to the best of his ability, and satisfy himself thereby, of the apparent future value of the men. This is the proper method to adopt in order to keep the organization up to standard; that is to say, it is the proper beginning, and let it extend down to the

end of the line, even to the cleaners, for there are good cleaners and bad ones, especially on electrical machinery.

Storage-Battery Division

Of the organization to operate storage batteries, I will say I believe that the cheapest man to have at the head is one who is both technical and practical in that line of work, and that he should be possessed of the same qualifications as are necessary in other heads of divisions with reference to handling men; but there is this to add, that it is seldom that men will work in the general line of storage-battery repairs for any considerable length of time, in that such work is not of the sort that attracts the average man, and they do not stay long enough to actually show of what value they might be after a reasonable period of service.

Head of Department

I have refrained from speaking of the head of the generating system and the assistant to that person, for the reason that it seemed to me proper to look over what there was in the nature of organization and operation that the head and his assistant were called upon to look after. I now say that the head of the department has responsibilities as follows:

First—The very important one of the organization of his department. If that be correct, or as nearly so as conditions will permit, the operating responsibility, broadly speaking, will not seem as serious to the head of the department as it would under the more unfavorable condition of lax discipline in the handling of heads of divisions and men who have severally decided that the head of the department is in his position for the sole purpose of bearing his title instead of directing the operation of the generating system. He should not only pass his orders on operation to his assistant, but in addition should see to it that they are carried out. He should carefully observe the result, and be ready to devise, if possible, methods of saving to his several accounts, as the total of these will represent his total generating cost. He should not, however, overdo the looking after of small details, for several reasons. First, because he has an assistant and several heads of divisions, who occupy positions and are paid salaries for the purpose of looking out for that portion of the

business; and if they don't do it and relieve him in that direction, then either the organization or the discipline or both are not correct, and it is absolutely useless for him to expect to proceed on a successful basis until his own error, whether caused by neglect or otherwise, is corrected, and his people understand in a thorough manner that the head of the department is there to direct its operation.

The head of the department should also keep in touch with the intentions of his heads of divisions relative to their hiring of men, and not only confer with them in a general way on such matters, but lay down a rule that men connected in any way with matters detrimental to the interests of the corporation should not be hired in any event. He should include in such a rule a stipulation that if men of such type get inside the organization notwithstanding proper precaution has been taken, they should be relieved from further connection with the department at once and be replaced by men of a different class.

I have found by some years of experience that to pay one line of work a standard wage, whether it be lower or higher than the so-called "union" scale, is productive of more contentment and better sentiment toward the employer than anything else I know of; but in order to do this consistently we must, as I have mentioned before, be careful to select a class of men who are very nearly alike with reference to the amount and quality of work which they can perform. Such a thing can be done easily, as I know by actual experience.

It does not seem necessary to say that the head of the department should not absent himself from the system or from his office for any length of time without giving notice where he can be found in case of emergency, and the assistant and heads of divisions should be required to observe the same rule; for while such a rule may seem to be somewhat of a hardship at first, on second thought we can easily imagine cases where it would be most unfortunate not to be able to avail oneself of the services of one of the best men in his department just because one is unable to locate him; and besides, such a rule removes any chance of inference being drawn which might be detrimental to the man.

The head of the department has at times to go farther than his office to get at the reason of the rise in some account which seems abnormal. He must, after exhausting other methods,

simply get in and dig it out; get the reason, and see if it is a proper one, and if not, apply the remedy. If the reason is proper he is entitled to rest content, because he has assured himself that the rise in the account is not the result of reckless expenditure; if he finds a poor reason, he will strengthen his organization by taking the matter up with the proper party and going into it in a manner that can not be misunderstood, and show where it is to the advantage of all concerned to make that expense nearer the proper amount.

It sometimes happens that difficulty occurs between some of the men and their superior, in which the man from the ranks feels that he has been misused; that his superior has been too hard on him because his advantage of position has given him the privilege. In such cases, after the man has taken his trouble to the chief of his division and even then feels that he has a grievance, I believe it to be good policy to allow him to see the head of the department as a last resort; for the head to call in all parties concerned at one time and hear the several stories, one at a time, and decide the matter. Of course, if the superior has used his position properly there can be but one result; if he has not, and you have to decide the man is not to blame, then be sure you have that man understand beyond a doubt that he can not and must not mistake a just decision for a license to disobey in the future, but that he is bound to work for and obey the same superior, just as much as he was previous to the time when the difficulty occurred.

It therefore seems that there are a good many places where the head of the department can put in his services and benefit the organization, and if he can find the necessary time to walk out and through his system, even though he does not speak at all, no doubt he can see spots that will bear criticism, and it is for him to note them and, as I said before, "apply the remedy."

For the head of a department to say to himself, "We are now organized and operating satisfactorily, there is nothing more in that line at present," is a rash statement even to himself, as he will soon find out if he does not watch what he has tried to put together so carefully. To watch the organization, and constantly, too, is what is in a large degree necessary to the attainment of a low cost per kilowatt-hour.

Assistant Head of Department

And now about the assistant to the head of the department. We will assign to that individual the duty of placing with the heads of the several divisions the orders given by the head of the department. We will ask him to see that the electrical instruments, steam gauges, and all other indicating apparatus, are kept at proper standard; to know whether the engines have been indicated; to keep in touch with the load, and the time of demand for the same, at its highest point and its lowest point as well, and thereby be enabled to suggest the advisability of changing the load from one station to another, with a view to obtaining the best economy possible with the fuel and water consumed and the expenditure for labor; to check the amounts of fuel consumed; to check and comment on the grade of fuel, and kick on the quality if necessary.

The assistant to the head of the department must necessarily be a man of technical ability and be able to take up the items heretofore set forth on that basis; for among the many small items, which when taken as a whole tend to lower the economy of operation, there are usually many that require analysis, and such analysis calls for the services of a man who is well versed in technicalities and who can get down to the bottom facts of such matters easily and quickly and open the way to apply the proper remedy.

He will also act for the head of the department in his absence, and follow closely and report any irregularities in operation, machinery or labor; and it is the duty of the head of the department to invest his assistant with such authority as will enable him to perform such duties in a clear and intelligent manner, with the only stipulation that his treatment of all the parties concerned shall be of a kind that will stimulate good feeling in the department and at the same time not interfere in any manner with good discipline.

In fact, the duties of the assistant to the head of the department are manifold, and of great value if properly performed. He is in his position the second in the amount of responsibility taken, and should most fully realize it and endeavor to protect that position with his ability to look into the future far enough to warrant that the service of the company will not suffer and that the expenditure made to manufacture the output will be as low as is consistent with good service and operation.

In the foregoing matter I have endeavored to place before the association an outline of the generating department organization of the Boston Edison company; and, finally, I wish to say that whatever success we have attained in this direction has been due to efforts to secure a close and constant co-operation throughout the department; to the maintaining of a discipline which has been necessary and warrantable, but which has been established and maintained with justice and tempered by kindness. In other words, there has been the disposition on the part of the company and of the department to show every employee that his position had a value both to the company and to himself; to show that the value of the position to the employee was what the employee himself could make it, aided by the counsel and instruction of the superior who held his services in immediate charge; and to show that by paying a uniform rate of wage for a uniform quality and quantity of labor in every line, the company had adopted a treatment of its men conducive to contentment and was reasonable in assuming and expecting it.

DISCUSSION

THE PRESIDENT: Gentlemen, you have heard the paper; have you any remarks to make upon it?

MR. W. B. JACKSON (Madison, Wis.): It seems to me that such a paper should be given further commendation than the mere applause of this audience, because the author ably considers a feature of station operation that is of great importance, not only to those operating large plants, but, as I follow Mr. Hancock's paper, it is such that those interested in all plants, large, small and intermediate, may benefit; especially considering the suggestive characteristics in the author's treatment of the subject.

One point worthy of note Mr. Hancock did not bring out, though I feel that he probably intended to do so. In his reference to the keeping of the plant clean, he spoke of its value to the company owing to the effect a cleanly appearance would have upon visitors who might be future purchasers of power, and even upon present customers, in giving evidence of a concern capable of supplying reliable service. Not only is there a benefit of this character derived from keeping a plant clean and orderly, but the morals of employees will also be improved and

their work be much more effective. This is obvious from the fact that when one enters a dirty plant one finds slovenly employees and upon entering a clean, orderly plant one sees bright, energetic employees, who are interested in their work and who appreciate their responsibilities.

MR. A. H. KRUESI (Schenectady, N. Y.): There seems to be a conflict between the policies indicated on pages 124 and 128 in regard to the wages of the men. Emphasis is laid on the importance of paying firemen a uniform wage, whereas a contrary policy is apparently followed with regard to the electrical operators. The reason is not apparent.

MR. HARTMAN: I ask Mr. Hancock—if is not too leading a question—the cost of labor per kilowatt-hour in his steam and electrical departments.

MR. HANCOCK: I did not bring these figures with me to the meeting, but I have them in the house and shall be glad to give them to you at any time. I do not try to carry these costs in my memory. They are all figured on the kilowatt-hour basis.

In answer to Mr. Kruesi's question, that is a case of the firemen and the employees in the operating department. We do not hire any beginners for firemen. We hire a fireman at $16 a week, and if he is not worth that we do not want him. In the case of operators, we take them in as low as $10 a week and move them up as fast as we can. They begin at the bottom of the line.

MR. ORVILLE A. HONNOLD (Salt Lake City, Utah): I ask if the firemen and operators are kept interested in any way in the results of their work.

MR. HANCOCK: They are.

MR. HONNOLD: I find it a good scheme to keep a curve of the cost of the different departments and show the men these curves and let them see whether they are increasing or decreasing costs. In our case they take pride in keeping the curve tending down hill. This can be done without giving them actual figures.

MR. HANCOCK: Nearly all my operators and chief engineers know about these things every month, and they know about it in dollars and cents—they see how much they are saving or losing.

MR. HARTMAN: There is one question I will ask—it is rather a delicate one. Mr. Hancock speaks a number of times about

labor troubles—about the unions. My experience shows that where the men are well paid and well treated the trouble generally comes from the outside and not from the men themselves. I should like to know what Mr. Hancock's practice is in dealing with those cases.

MR. HANCOCK: I have not a union man on my pay-roll. I do not want him there and I do not need to have him there, for the reason that we pay a higher scale of wages than the union. Furthermore, I consider my men are far above the average of men who are in the unions to-day. That is why I said I did not want a fireman worth less than $16 a week. The union scale in Boston is $14 a week. The delegates of the union call upon me and when I tell them we are paying a better scale of wages than they are, and as a rule we have a better class of men, they have nothing to say.

MR. SCOVIL: Is it true that there is no union labor in the Boston station?

MR. HANCOCK: It is a fact.

MR. SCOVIL: I know it is one of the most difficult things to keep the linemen out of the unions. A lineman in the ordinary electric-light station is obliged to go all over the city, and he is frequently accompanied by but one or two associates. In our town the telephone companies are employing union labor, and as a rule it has been difficult for us to maintain our independence, but we have succeeded in keeping our linemen from becoming union men. It was done only by paying more wages than they could get as union men. Our efforts in this direction resulted in considerably shutting down some new work at one season of the year. Good wages alone will sometimes help a company in keeping union labor out of the plant.

MR. DUNHAM: For the last three years we have given our men an annual dividend of six per cent on the total of their year's wages, and there has never been an opening for a union man since we did that.

THE PRESIDENT: We will now take up the report of the committee for the investigation of the steam turbine, of which Mr. W. C. L. Eglin, of Philadelphia, is chairman.

Mr. Eglin presented the following report:

REPORT OF THE COMMITTEE FOR THE INVESTIGATION OF THE STEAM TURBINE

Mr. President and Members of the National Electric Light Association:

Your committee has endeavored to keep in touch with the progress made in steam turbine practice during the past year, and has visited a number of plants, besides being in communication with the manufacturers. Letters have been sent to all of the users of steam turbines in central stations in the United States who have turbines operating generators under regular load. Inquiry has also been made of certain isolated plants which are operating fair-sized units.

The committee also visited the works of the General Electric Company at Lynn and Schenectady, Westinghouse Machine Company at Pittsburg, and the Hooven-Owens-Rentschler Company, Hamilton, O., and discussed with the engineers of these companies those subjects which came to the attention of the committee, and in its judgment deserved consideration.

The marked improvements in the manufacture and the great development of the steam turbine during the past year must be noticeable to even the most casual observer.

The best index of progress made in steam turbines is shown by the number of turbines now installed, or manufactured ready for installation. There are in operation 224 turbines, of an aggregate capacity of over 350,000 horse-power in the larger size units in the United States, the greater number of which have been installed within the past two years. The following list shows the number of machines installed and their location:

5000-Kw

2	The Edison Elec. Ill'g Co., Boston, Mass.
3	The New York Edison Co., New York.
3	Chicago Edison Co., Chicago, Ill.
2	St. Louis Transit Co., St. Louis, Mo.
10	

3000-Kw

3	Edison Ill'g Co. of Detroit, Detroit, Mich.
1	United Elec. Co. of New Jersey, Newark, N. J.
4	

2000-Kw

2 Potomac Elec. Power Co., Washington, D. C.
2 The Edison Elec. Co., Los Angeles, Cal.
5 Old Colony St. Ry. Co., Boston, Mass.
1 Boston & Worcester St. Ry. Co., Boston, Mass.
2 St. Louis Transit Co., St. Louis, Mo.
1 Georgia Ry. and Elec. Co., Atlanta, Ga.

13

1500-Kw

1 Port Huron Lt. and Pr. Co., Port Huron, Mich.
1 St. Joseph Ry., Lt., Ht. and Pr. Co., St. Joseph, Mo.
1 Syracuse Ltg. Co., Syracuse, N. Y.
1 Omaha Elec. Lt. and Pr. Co., Omaha, Neb.
1 Houston Ltg. and Pr. Co., Houston, Tex.
1 Nassau Lt. and Pr. Co., Roslyn, N. Y.
1 Nashville Ry. and Lt. Co., Nashville, Tenn.
2 Portland General Elec. Co., Portland, Ore.
2 Tokio St. Ry. Co., Ltd., Tokio, Japan.

11

500-Kw

Direct-Current

1 Cork Tramways, Cork, Ireland.
1 Northern Ohio Traction Co., Akron, Ohio.
2 Penna. R. R. for Greenville Shops, Greenville, N. J.
2 Christ Church Municipal Tramways, Christ Church, New Zealand.

Aternating-Current

2 B. T. H. Co., Rugby, England.
1 Binghamton Lt., Ht. and Pr. Co., Binghamton, N. Y.
1 Macon Ry. and Lt. Co., Macon, Ga.
2 United Gas and Elec. Co., Dover, N. H.
3 Newport & Fall River St. Ry. Co., Newport, R. I.
2 Nashua Lt., Ht. and Pr. Co., Nashua, N. H.
3 Chattanooga Lt. and Pr. Co., Chattanooga, Tenn.
7 D., L. & W. R. R. Co., Scranton, Pa.
2 La Clede Lt. and Pr. Co., St. Louis, Mo.
2 Richmond Lt. and Ry. Co., Staten Island, N. Y.
2 Winona Ry. and Lt. Co., Winona, Minn.
3 Union Elec. Co., Dubuque, Iowa.
1 Phœnix Lt. and Fuel Co., Phœnix, Ariz.
1 Lynn Gas and Elec. Co., Lynn, Mass.
1 Westchester Ltg. Co., New Rochelle, N. Y.
2 Fulton Bag and Cotton Mills, Atlanta, Ga.
2 United Gas and Elec. Co., New Albany, Ind.
1 U. E. G., Berlin, Germany.
3 Lane Cotton Mills, New Orleans, La.
2 Columbus Ry. and Lt. Co., Columbus, Ohio.
2 Saginaw Valley Traction Co., Saginaw, Mich.
1 Consolidated Gold Fields of South Africa, Ltd.
1 Witwaters Rand Deep Gold Mining Co., Ltd., South Africa.
2 Tokio St. Ry. Co., Tokio, Japan.
1 Economy Lt. and Pr. Co., Joliet, Ill.
1 Monterey Elec. Lt. and Pr. Co., Monterey, Mexico.
1 Meridian Lt. and Ry. Co., Meridian, Miss.

1 Terre Haute Elec. Co., Terre Haute, Ind.
1 Edison Elec. Lt. Co., Philadelphia.
1 John Morrell & Co., Ltd., Ottumwa, Iowa.
1 Hot Springs Water Co., Hot Springs, Ark.
2 Victor Mfg. Co., Greers, S. C.
1 Municipal Plant, Jacksonville, Fla.
1 Public Service Corporation, Metuchen, N. J.
2 United Shoe and Machinery Co., Beverley, Mass.
2 Marion Ltg. and Htg. Co., Marion, Ind.
1 Oshkosh Elec. Lt. and Pr. Co., Oshkosh, Wis.
1 International Lt. and Pr. Co., El Paso, Tex.
1 Electric Lt. Co., Mobile, Ala.
1 Mobile Lt. and Pr. Co., Mobile, Ala.
2 Havana Gas and Elec. Co., Havana, Cuba.
3 Yokohama Union Elec. Lt. Co., Yokohama, Japan.
1 Tokio Elec. Lt. Co., Tokio, Japan.
2 Easton Gas and Elec. Co., Easton, Pa.
2 Mexico Lt. and Pr. Co., Mexico City.
2 Zanesville Ry. and Lt. Co., Zanesville, Ohio.
2 Mitsui & Co., for Osaka, Japan.
5 Mitsui & Co., for Tokio, Japan.
1 Oji Paper Mills, Japan.
1 Nagoia Elec. Lt. Co., Japan.

5500-Kw

1 Interborough Rapid Transit Co., New York, N. Y.
3 Pa., N. Y. & L. I. R. R., Long Island City, N. Y.

1500-Kw

1 Hartford Elec. Lt. Co., Hartford, Conn.
4 Philadelphia Rapid Transit Co., Philadelphia, Pa.
1 Pelzer Mfg. Co., Pelzer, N. C.
1 DeBeers Consolidated Mines, Kimberley, South Africa.
1 Manila Elec. Ry. and Ltg. Co., Manila, P. I.

1250-Kw

3 Interborough Rapid Transit Co., New York, N. Y.

1200-Kw

1 Baltimore Copper Smelting and Roller Co., Baltimore, Md.

1000-Kw

2 DeBeers Consolidated Mines, Kimberley, South Africa.
3 West Penn. Ry. and Ltg. Co., Connellsville, Pa.
2 Cleveland So. Western Traction Co., Elyria, Ohio.
2 West Virginia Pulp and Paper Co., Piedmont, W. Va.
2 United Elec. Lt. Co., Springfield, Mass.
2 Tokio Elec. Lt. Co., Tokio, Japan.

750-Kw

2 Hartford Elec. Lt. Co., Hartford, Conn.
1 B. F. Goodrich Co., Akron, Ohio.

2 Westinghouse Elec. and Mfg. Co., East Pittsburg, Pa.
2 Merchants' Ht. and Lt. Co., Indianapolis, Ind.
2 N. Y., N. H. & H. R. R. Co., Warren, R. I.
1 U. S. Navy Yard, Boston, Mass.
3 Manila Elec. Ry. and Ltg. Co., Manila, P. I.

500-Kw

1 Lewiston Water and Pr. Co., Lewiston, Idaho.
1 Penna. Lt., Ht. and Pr. Co., Allegheny, Pa.

400-Kw

4 Westinghouse Air Brake Co., Wilmerding, Pa.
2 Yale & Towne Mfg. Co., Stamford, Conn.
1 B. F. Goodrich Co., Akron, Ohio.
2 Consolidated Railroad and Ltg. Co., Wilmington, N. C.
1 Johnston Harvester Co., Batavia, N. Y.
2 Roslyn Lt. and Pr. Co., Roslyn, N. Y.
1 S. D. Warren Co., Cumberland Mills, Me.
2 Saco & Pettee Machine Shops, Biddeford, Me.
1 Rockland Lt. and Pr. Co., Nyack, N. Y.
2 Citizens' Lt., Ht. and Pr. Co., Johnstown, Pa.
3 City of Columbus Municipal Plant, Columbus, Ohio.
1 Atlantic Mills, Providence, R. I.
2 Portsmouth St. Ry., Portsmouth, Ohio.
1 Hot Springs Elec. Co., Hot Springs, Ark.
2 Anderson Municipal Lighting Plant, Anderson, Ind.
1 Sherwin-Williams Co., Cleveland, Ohio.
1 Eaton Cole & Burnham, Bridgeport, Conn.
1 J. Benn & Sons, Inc., Providence, R. I.
2 Iowa & Illinois Ry. Co., Clinton, Iowa.
1 Parkersburg, Marietta & Interurban Ry., Parkersburg, W. Va.
1 Madison Gas and Elec. Co., Madison, Wis.
2 Newhouse Mines and Smelter Co., Cactus Mine, Utah.
2 Union Metallic Cartridge Co., Bridgeport, Conn.
1 Belleville Portland Cement Co., Belleville, Ont.
1 Canadian Klondike Mining Co., Dawson, Alaska.
1 Rome Brass and Copper Co., Rome, N. Y.
1 Grays Harbor Elec. Co., Aberdeen, Wash.
1 The Henrietta Mills, Henrietta, N. C.
1 California Powder Co., Pinola, Cal.

300-Kw

2 Philadelphia, Coatesville & Lancaster Ry., Coatesville, Pa.
1 Northern Elec. Co., Montreal, Canada.

A comparison can be made between this list and that given in our previous report.

The object we have in view in publishing this list is two-fold; first, to show the progress that has been made, and, second, that the member companies that are not users of steam turbines may inspect plants in their vicinity.

The committee has made selections from this list, and has conducted tests in the stations of the owners to obtain data as to results of steam turbines under actual operating conditions.

It has also endeavored to bring to the attention of the manufacturers any weaknesses or defects that have developed in their machines during the past year, and this is treated in that section covering the visits to the works of the manufacturers.

Attached is a tabulated statement showing the replies to the committee's letters from the users of steam turbines.

A special inquiry has been made into the condensing apparatus most suitable for steam turbines. This inquiry was conducted on the same lines, and letters were sent to all of the users of steam turbines, asking specific questions; also to the manufacturers of condensing machinery.

Ninety-five different companies were written to for information in reference to the use of turbines and fifty-nine companies furnished as complete reports as their operating conditions would allow. This portion of the report, therefore, presents a summary of data from

Fifty-seven Curtis turbines having a total capacity of 83,500 kilowatts.

Thirty-four Parsons turbines having a total capacity of 19,800 kilowatts.

Nineteen De Laval turbines having a total capacity of 1686 kilowatts.

Table No. 1 gives the name of each company, its location, the general characteristics of the turbine installation, and its operating conditions.

Special effort was made to obtain from the users a complete statement of troubles due to the use of turbines. It is interesting to note that everyone seemed well satisfied with their machines and very few companies admitted that they had any trouble whatsoever from the turbine itself.

One company, operating Curtis turbines, reported one shutdown caused by a worn bearing on the tachometer drive vibrating the rod operating the latch on the emergency stop valve. This resulted in the emergency valve closing suddenly without any warning. The same company also reported slight trouble with the generator, due to loose laminations in the armature. The latter trouble was discovered and remedied before any damage was done.

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On another Curtis turbine, the users experienced some little difficulty with the needle valves and the main nozzle valves, due to warping caused by the high degree of superheat used in the plant.

On another turbine of this type some trouble was experienced from air leakage in the turbine and also from water mixing with the oil lubricating the step-bearing. This company also states that it had some trouble with the condensing apparatus, but omits to state just what the trouble was.

On a De Laval turbine, one company reports some trouble due to design of the brush-holders on the dynamo, which was easily remedied.

On another De Laval turbine, trouble was reported with the oiling. This seemed to be due to the filling up of the spiral oil-ways which stopped the flow of oil, and was overcome by the use of special oil carefully filtered.

One company using Parsons turbines reported some difficulty in the matter of lubrication. The oil, which worked well in one part of the machine, solidified into a jelly and failed to work in some of the other bearings.

On another Parsons turbine, trouble was reported due to the repeated cutting out of the throttle valve seat, which tended to cause the turbine to race on light loads. This difficulty was attributed to the peculiar water used in the locality. They also report trouble from excessive vibration of the turbine, caused by the expansion of the exhaust pipe throwing the turbine out of line. This developed some months after the turbine was started and was entirely corrected by installing an expansion joint in the exhaust pipe.

Two Parsons turbines are reported to have encountered trouble with the field coils of the generator, both machines burning out under less than normal load. This is apparently due to an error in the design. They have had some difficulty with the breaking of the brass sleeves of the concentric bearing. They also report that they find it necessary to give the lubricating system special attention to avoid trouble with it.

One report has been received on a Parsons turbine stating that a large number of the blades were lost because the turbine was started too quickly. Superheated steam was being turned on and sufficient time was not allowed in warming up the machine to

maintain proper clearance between the tips of the blades and the casing.

On another Parsons turbine trouble is reported from many of the blades of the rotor breaking while running and without rubbing. This is considered later in the discussion of the Parsons turbine.

Another company, operating several Parsons machines, reports it has had a few blades broken out of one of its turbines due to some foreign substance being carried into the turbine through the steam pipe. This did not affect the operation of the turbine, which was continued in service until it was convenient to shut it down and repair it.

It will be seen from the above that all troubles reported were of a minor character, and, considering the aggregate capacity of the machines in use and making due allowance for the reticence of the people owning them, that the troubles and difficulties experienced in turbines are very few and comparatively insignificant. In fact, they seem to be much less than might be expected in the use of reciprocating engines of similar size.

Your committee has also endeavored to obtain some information on the operating costs of turbine-driven units in order to draw a comparison between the efficiency of turbines and reciprocating engines as prime movers. Very few stations were able to give any satisfactory data on this, which is mainly due to the fact that in many stations turbines are being operated in connection with engines, so that it is difficult to separate the charges. In a number of other stations, the installation was comparatively new and the company did not feel that it could give any satisfactory information under this head. Sufficient replies, however, were received from various parts of the country to give a very good general idea of what should be expected from a turbine installation.

Broadly speaking, the operating cost, exclusive of fixed charges, is lower than that of reciprocating engines operating under the same conditions, on account of the reduction of labor and incidental expenses.

GENERAL ELECTRIC COMPANY

CURTIS STEAM TURBINE

The turbine works of the General Electric Company, both at Lynn and Schenectady, were visited, and the committee discussed

with the engineers of the company at both works the use of the mechanically operated valve in place of the electrically operated valve, which is at present the standard practice. One mechanical type is operated by power transmitted from the turbine shaft by means of a worm wheel and gearing. The valve mechanism is similar in many respects to a poppet valve gear, the governor controlling two dogs, one of which is arranged to open and the other to close the valve. This valve gear was designed by Mr. Richard H. Rice, who has had considerable experience in engine practice, and follows closely the best lines developed from engine experience. The governor control is similar to the present method; the number of nozzles open is varied by the demand on the turbine and is controlled by the centrifugal governor in the usual way.

The other mechanical type is operated hydraulically, a water piston giving reciprocating motion to a rod controlling a bank of valves that are opened by means of a cam and closed by a spring. The governor controls a pilot valve which in turn operates the hydraulic piston, the motion of which is transmitted to the cams that open the valves. In the first case the valves are thrown open or closed, and in the second there is a throttling action of the valves. These valves have not been in use long enough to give any definite data regarding their operation.

The first type appeals favorably to the committee on account of its simple mechanical construction, and it would appear to be a reliable and effective device.

The one objection to be raised to the mechanical form of valve is that it necessitates the use of a small number of valves of large area, and some criticism has been raised that the regulation of the turbine will not be so good with that type of valve as with the larger bank of valves of smaller diameter that are electrically operated.

The accompanying illustration (Figure 1) shows the first type of mechanical valve gear for turbines developed by the General Electric Company as mentioned above. Briefly stated, the nozzle valves are directly actuated by cam plates, one cam plate being provided for each valve. The cam plates are loosely mounted on a rock shaft and are adapted to be moved in one direction or the other to open or close the valves by dogs carried by steam levers. As many of these steam levers are provided as there are cams and valves. The steam levers are keyed

to the rock shaft and the latter is continually moved to and fro by means of suitable cranks and a connecting rod from a worm gear driven by the main shaft.

In addition to the above, each valve is provided with a shield plate loosely mounted on the rock shaft, the shield plates being set angularly one behind the other to obtain the successive actuation of the valves, and rigidly connected together. The shield plates control the action of the dogs on the cam plates. That is to say, when more steam is required, a shield plate permits the proper dog to engage and move a cam to open a valve. Conversely, when less steam is required, a plate permits another dog engage and move a

FIG. 1

cam to close a valve. Each valve is opened or closed by one stroke of its steam lever. The only work required of the shield plates is to move the dogs, and this when they are out of engagement with the cam plates. The shield plates are moved by the shaft governor in response to speed changes. It will thus be seen that the power for opening and closing the valves is taken directly from the main shaft.

When two sets of admission valves are employed the mechanism above described is duplicated, suitable provision being made for obtaining the proper direction of movement.

A very decided improvement has been made in the electrically controlled valves by placing the springs and stems outside of the

casing, and in certain details in the construction of relays and pilot valves.

The latest type of electrically operated valves appears to be working satisfactorily.

The throttle valve and emergency stop formerly used on the Custis turbine were not considered satisfactory. Improvements have been made and the gate valve has been superseded by a double-seat, balanced globe valve with emergency stop attachment.

The brake applied to some of the earlier types of turbines has been abandoned, and is not considered part of the standard machine. It has been found in practice, however, that the brake was useful in holding up the weight of the revolving parts when repairs or examinations were being made on the machine, and the company was asked to take under consideration the advisability of adopting on all of the larger sized machines an attachment similar to the brake for this purpose, and they will furnish in the larger sizes such an attachment as part of the standard machine when so specified.

The question of the changes in speed of the standard 1905 turbine as compared with the 1904 was discussed and it was found that there were only two sizes in which any changes in the speeds as previously given were contemplated. A tabulated list showing standard sizes and speeds is as follows:

ALTERNATING-CURRENT

VERTICAL SHAFT.—60 CYCLE

Class	Poles	Kw.	R. P. M.	Volts
ATB	4	300	1,800	240- 4,000
"	4	500	1,800	240- 6,600
"	6	1,000	1,200	480- 6,600
"	8	1,500	900	480- 6,600
"	8	2,000	900	1,150-13,200
"	12	3,000	600	600-13,200
"	10	5,000	720	2,300-13,200

25-CYCLE

Class	Poles	Kw.	R. P. M.	Volts
ATB	2	300	1,500	370- 6,600
"	2	800	1,500	600-13,200
"	4	2,000	750	2,300-13,200
"	4	5,000	750	2,300-13,200

DIRECT-CURRENT

HORIZONTAL SHAFT

Class	Poles	Kw.	R. P. M.	Volts
C	2	15	4,000	80-125
"	2	25	3,600	125-250
"	4	75	2,400	125-250
"	4	150	2,000	125-250
"	4	300	1,500	125-550

VERTICAL SHAFT

Class	Poles	Kw.	R. P. M.	Volts
C	4	500	1,800	550

There are various opinions held as to the maximum clearance allowable in this type of turbine without interfering with the efficiency, and we attach hereto a list of clearances recommended by the company, which is given for each stage. It may be said that the opinion is now held by the General Electric Company that the amount of clearance imposed by the mechanical conditions does not in any way affect the efficiency of the turbine. This is especially true of the four-stage type of machine.

TURBINE		CLEARANCES			
Rating	Stages	1st Stage	2d Stage	3d Stage	4th Stage
500	4	.06 inch	.06 inch	.06 inch	.06 inch
800	4	.07 "	.07 "	.07 "	.07 "
1,000	7	.08 "	.08 "	.08 "	.15 "
1,500	4	.06 "	.06 "	.06 "	.08 "
2,000	4	.06 "	.06 "	.08 "	.08 "
3,000	4	.07 "	.07 "	.07 "	.08 "
5,000	4	.07 "	.07 "	.07 "	.08 "
5,000	6	.10 "	.1 "	.1 "	.2 "

The question of noise in the generator was also discussed. It was found that there are several sizes of generators that operate practically noiselessly, while others make considerable noise. This is being overcome by changes in the design of the revolving field in order to obtain a smooth surface. The revolving field of the

machine making the most noise has been redesigned, and the field windings used being distributed windings, which remove all of the sharp edges, leaves practically a smooth running surface, so it may be said that this question is now solved.

A lengthy discussion was held to determine the advisability of using a two-piece shaft with a coupling on the larger sizes of turbines. At first these machines were built with a two-piece shaft and later a one-piece shaft was adopted as a standard. The committee was unanimous that the two-piece shaft was better adapted for the requirements in the central station in facilitating the removal of the revolving field, and there was less danger of the shaft being sprung than the one-piece shaft, in which case the revolving field would require to be drawn off the shaft. The company stated that the use of a coupling will increase the total height of the machine, which is serious where head room is limited. A coupling can always be furnished when specified. However, the company does not think it advisable at the present time to adopt the two-piece shaft as its standard construction.

The committee found that certain parts of the turbine were not interchangeable; as an example, the valve chambers could not be reversed and allow steam to be brought from either side of the turbine without some fitting. We also requested that uniform spacing of bolt-holes on the flanges on the sides of the turbine, including the casing, should be considered. This, the company stated, will be strictly adhered to, so all valve chambers can be reversed if necessary, and, also, the position of the turbine, with reference to the base, can be turned to any angle represented by the distance between the two adjacent bolts.

In the works at Lynn the smaller sizes of turbines are being built up to and including 1500 kilowatts. At Schenectady the larger sizes are being built up to and including 5000 kilowatts.

Extensive improvements were evident in both shops. The most important advances made since the last report were changes in the construction of the wheels so as to form a smooth surface by the removing of all bolt heads and ribs, bolts being substituted by countersunk rivets, thus reducing the friction of the revolving parts. Important changes have also been made in the shapes of the buckets and in the construction of the nozzles. These changes have all been made with the object of improving the economy of the machine.

Step bearings are now being operated with water instead of oil, and the construction has been modified to admit of this change. We have been unable to find a single case where the step bearing has given any serious trouble.

At Schenectady great care has been used in fitting up a complete testing station for steam turbines. The apparatus and the methods have been given most careful attention. The committee spent some time here and a test was run off to show the methods employed and the apparatus used in the test, and we believe it is the most complete and efficient testing apparatus that has ever been used for testing machinery in a manufacturer's works, and there should be no difficulty in duplicating tests with accurate results.

A test was also made in starting a 1500-kw turbine from rest to find the time necessary to bring the machine up to full speed, synchronize it and put full load on it. The machine was brought up to speed, synchronized, and loaded with full load in one minute and ten seconds. It was brought up from rest to full speed in a little less than one minute.

THE WESTINGHOUSE MACHINE COMPANY

PARSONS STEAM TURBINE

The committee visited the works of the Westinghouse Machine Company, Tuesday, March 21st, and discussed with Messrs. Sniffin and Brinsmeade the question of proposed tests on the Westinghouse Parsons machines installed in regular stations.

The committee was also shown over the works of the Westinghouse Machine Company. The amount of work in the shops is very much greater than during the visit previous to the last report of your committee. In fact, it would appear that the larger portion of the shops is given over entirely to the construction of turbines.

The various sizes of turbines are now being standardized and the number of standard sizes has been very materially increased. A year ago there were only three or four standard sizes, and this year they are prepared to offer twelve sizes of turbines. These machines are being constructed on shop orders in quantities so as to obtain a uniform construction and shorten the time required to make delivery.

The type of the turbine remains practically the same, although some of the modified forms being experimented with last year have been abandoned, the type known as the two stages having been dropped. This was really not a two-stage turbine, but the wheels of larger diameter were placed in a separate casing, by which, at that time, it was thought some advantage could be gained in economy by reheating the steam between these two stages. It was found in the experiments this could not be accomplished, and as it was more expensive, it was dropped. Now all the sizes are practically on the same line, merely increasing in size to provide capacity, with the exception of certain sizes operating at lower speeds. In these sizes the diameter of the wheels is very much increased.

Particular attention is now being given to the blades, and some of the machines now being built have steel blades, and some blades of various alloys.

The most important improvement in the construction of the blading is the addition of a flat lace of steel which is threaded through openings near the outer edge of the blades and fastened by twisting the flat steel lace between each blade. This performs two functions: first, it maintains a uniform spacing between the outer edges of the blades; and, second, it increases the mechanical strength of the blades and prevents vibration. In the larger sizes the longest blades are made from drop forgings with special ends which are machined so as to fit in a dovetailed groove and fastened at the outer end by means of the band lacing previously described.

The joint in the lacing is made by introducing a second lace nearer the shaft, the blades at the joint having two holes punched, and a short piece of wire is arranged at the break of the outer lacing strip to lap the joint. Tests have been made to see whether this band strip in any way affects the efficiency. Thus far, however, these bands have not shown any change. It is expected that this lacing will overcome most of the trouble that has been experienced in the failure of blades.

The standard sizes and speeds of 25 and 60-cycle turbines are as follows:

200 1850 direct-current

	R.P.M. 60-Cycle	R.P.M. 25-Cycle
300	3600	1500
400	3000	....
500	3600	1500
750	1800	1500
1000	1800	1500
1500	1200	1500
2000	1200	1500
3500	720	750
5000	720	750
6000	720	750
7500	720	750

Some minor changes have been made in the oiling system. The old system of oiling was to pump the oil through cooling coils to a tank arranged above the turbine to obtain a static head of two or three feet of pressure on oil bearings. This has been changed to a closed tank, and a pressure is maintained in the tank of about seven pounds by means of a by-pass valve controlled by the pressure on the tank. This change was made on account of insuring constant and liberal flow of oil on all bearings without largely increasing the size of the storage tank.

The mechanical workmanship on all of the parts is excellent. The grade of both the cast-iron and steel is exceptionally good.

The company is experimenting with a double-flow turbine in which the steam is admitted at the centre and expands through the turbine to the outer ends, being connected to the exhaust opening to the condenser. This has a number of mechanical advantages. First, it obviates the necessity of connecting pipes through balancing pistons and various pressure points, it shortens the length of the shaft, and more than doubles the capacity of the turbine of the same length.

The machine is merely in an experimental stage, and sufficient tests have not been made to learn whether the economy is as good as that of other types. It possesses a number of features, however, that appear to your committee to be worthy of mention and form an index of the possible future developments of this type of turbine.

HOOVEN-OWENS-RENTSCHLER COMPANY

HAMILTON-HOLZWARTH STEAM TURBINE

The committee visited the works of the Hooven-Owens-Rentschler Company, Hamilton, Ohio. This company is the builder of the Hamilton-Holzwarth steam turbine, but it has had but few of the machines in actual service. It is at present building several sizes, varying from 200-kw to 1000-kw. The operation of the turbine is as follows:

Steam is admitted through a stationary diaphragm in which is placed a continuous row of nozzles; this diaphragm could be called a fixed wheel. The steam is expanded in the nozzle and attains a certain pressure and velocity, which is nearly exhausted in the running wheel; then it passes through another series of nozzles arranged in the stationary wheel, the accelerating velocity being absorbed by the following wheel. This series of stationary nozzles and revolving wheels is increased until practically the entire energy of the steam is absorbed.

The mechanical construction is relatively simple. The cast-iron casing is bored to receive the stationary discs. These stationary wheels or discs are turned on all surfaces and a slot cut in the rim. Into the wheels are riveted drop forgings, which form the nozzles, and a band is shrunk around the outside so as to make a tight fit to the casing. The length of the buckets and the area of the nozzles are increased in each succeeding stage so as to take care of the increased volume of the steam due to its expansion through the machine. In the sizes now built the first row of buckets is about one-eighth inch long and the last about two inches.

The wheel is a built-up wheel. Two steel discs have pressed flanges riveted to a cast-steel centre. Two of these pressed-steel discs are mounted on a cast-steel centre, and in the slot between the discs are mounted the buckets, which are made from drop forgings. The tail piece that enters the wheel is drilled, all parts being held together by rivets. After the buckets have been set up and the wheel in rough shape, the spaces between the buckets are filled with babbitt metal and the whole wheel is then machined.

A recess is cut in the outer edge of the buckets so as to admit of the placing of a band which is held in place by riveting over the tips of the buckets, the two ends of the band being brazed at the joint. This construction is light, cheap and strong.

The turbine is controlled by means of a centrifugal governor mounted on the end of the shaft outside of the casing of the turbine. The governor valve is a balanced throttle valve, operated by a friction drive, which is controlled by a centrifugal governor, the shaft driving the governor being operated from a worm-wheel attached to the turbine shaft. Means are provided in the governor mechanism so that the friction wheel is not in contact with the disc except when the governor is in action, necessitating a change in the amount of steam admitted into the turbine, or vice versa.

The maker's list of sizes of turbine and their guarantees is as follows.

From what we have seen of the turbine we should like to call attention to the guarantees, but no turbine has been built and tested from these designs.

100-Kw, 3600 R.P.M.

125 pounds steam pressure, dry saturated, 27-inch vacuum

Full load	27.1 pounds per kw-hour
¾ load	29.4 pounds per kw-hour
½ load	34.0 pounds per kw-hour

200-Kw, 3600 R.P.M.

150 pounds steam pressure, dry saturated, 28-inch vacuum

Full load	22.2 pounds per kw-hour
¾ load	24.4 pounds per kw-hour
½ load	28.0 pounds per kw-hour

26-inch Vacuum

Full load	25.1 pounds per kw-hour
¾ load	27.5 pounds per kw-hour
½ load	31.6 pounds per kw-hour

200-Kw, 3600 R.P.M.

125 pounds steam pressure, dry saturated, 27-inch vacuum

Full load	24.8 pounds per kw-hour
¾ load	27.1 pounds per kw-hour
½ load	31.4 pounds per kw-hour

250-Kw, 3600 R.P.M.

125 pounds steam pressure, dry saturated, 27½-inch vacuum

Full load	24.7 pounds per kw-hour
¾ load	26.9 pounds per kw-hour
½ load	31.4 pounds per kw-hour

500-Kw, 1800 R.P.M.

150 pounds steam pressure, 100 degrees Fahrenheit superheat, 28-inch vacuum

Full load	17.5 pounds per kw-hour
¾ load	19.3 pounds per kw-hour
½ load	21.7 pounds per kw-hour

1000-Kw, 1800 R.P.M.

180 pounds steam pressure, 175 degrees Fahrenheit superheat, 27-inch vacuum

Full load......................	16.8 pounds per kw-hour
¾ load........................	18.0 pounds per kw-hour
½ load........................	20.0 pounds per kw-hour

1000-Kw, 1500 R.P.M.

175 pounds steam pressure (no superheat), 28-inch vacuum

Full load......................	18.6 pounds per kw-hour
¾ load........................	20.2 pounds per kw-hour
½ load........................	22.5 pounds per kw-hour

150 degrees Fahrenheit superheat

Full load......................	16.5 pounds per kw-hour
¾ load........................	17.6 pounds per kw-hour
½ load........................	19.6 pounds per kw-hour

During our visit we examined a 150-kw turbine that was set up in the shops. This machine ran 2400 revolutions per minute. It could not, however, be operated under load, as the generator had not arrived to be driven by the turbine. The turbine shaft was connected to the generator shaft by means of a flexible coupling. The bearings may be either ball bearings or babbitt metal, as the customer may elect. The company has entered into an arrangement with the Crocker-Wheeler Company, Ampere, N. J., to supply it with generators suitable for its turbines.

As has been stated, none of these machines has been tested in practical operation under load, and it is therefore impossible to express an opinion of its efficiency, but it is expected that in the near future some of these machines will be installed so that during the year data may be available as to their performances.

THE ALLIS-CHALMERS COMPANY

The Allis-Chalmers Company are now building a steam turbine similar in principle to the Parsons turbine, but with certain changes in the mechanical construction. This particularly affects the blading. The blading to be used by this company, we understand, is known as the Fullagher system. This blading is made in sections, a single row of blades being made in two sections which are held by bands at both ends, those bands in turn being peined in slots in the turbine casing.

The committee endeavored to obtain from this company a complete description with illustrations of the type of turbine being

built by them. Unfortunately, on account of patent reasons, the company were unable to give out any data for publication at this time. We have, however, their promise that we shall get it as early as possible, and it may be received in time to publish in the proceedings.

THE DE LAVAL TURBINE

We find the principal use to which this turbine has been put in central stations is in the operation of auxiliaries, principally pumps. There have been no new developments in this turbine during the past year, and we respectfully refer those desiring information regarding this turbine to the description given in the report of your committee last year.

THE ZOELLY TURBINE

The Zoelly steam turbine is now being manufactured in this country by the Providence Engineering Works, Providence, R. I. We have been unable to obtain from the manufacturers, however, any description of the machine that they build in time to insert it in the report.

CONDENSING APPARATUS FOR STEAM TURBINES

The committee has gathered from various sources, such as letters from the users of turbines, the manufacturers of turbine auxiliaries, technical discussion and its own experience, a few notes on the installation and operation of turbine auxiliaries, which it presents.

IMPORTANCE OF HIGH VACUUM IN TURBINE WORK

There still remains a small vestige of the reciprocating engine opinion in regard to the degree of vacuum at which to work. This matter has received much attention in the last three or four years, and while the practice seems pretty definitely settled in this respect, yet it will do no harm to go over the ground once more. We have taken the liberty of inserting a diagram, Figure 2, made by Sig. E. Vaunoti, of Milan, Italy, taken from the transactions of the Italian Electrical Society for 1904, which very adequately shows the relative importance of vacuum to the steam engine and to the turbine. It should be borne in mind that while the engine's use of vacuum is limited by the capacity and efficiency of the low-

pressure cylinder, the turbine is prepared to make full use of steam down to the lowest point of vacuum obtainable.

This diagram shows the adiabatic expansion of steam from 180 pounds absolute down to one pound of absolute back pressure. Within the expansion curve are laid the diagrams of a triple-expansion engine. The ordinates of the curve are pounds per

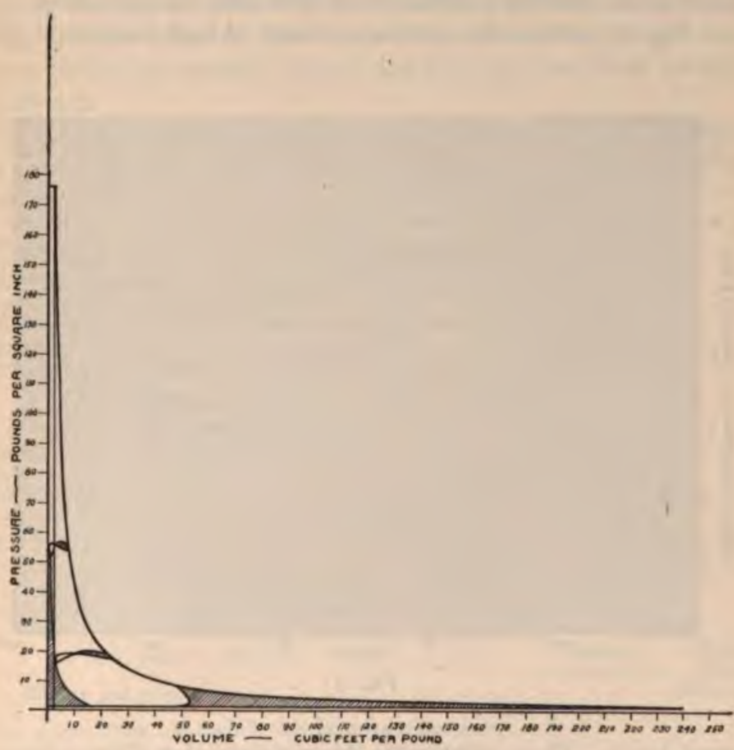

FIG. 2

square inch and the abscissæ the volumes in cubic feet per pound weight of steam. The shaded portion beyond the end of the low-pressure diagram illustrates the inability of the engine to use the immense amount of work left in the steam before it has completely expanded, down to one pound absolute. Naturally, the turbine does not convert all this energy, owing to losses from clearance, leakage, steam friction and radiation, yet these losses are of such

small proportion that this diagram most forcibly illustrates the immense advantage to the turbine of a high degree of vacuum.

Quite a number of experimenters have made tests to determine the economical effect of an increased vacuum, and it is interesting to note that these results approximate fairly close to each other. Three instances of the above are given for turbines of the Parsons type and one for the Curtis, results for which were collected by the Turbine Committee on tests made by themselves.

Figure 3 shows the relative economy of high vacuum at dif-

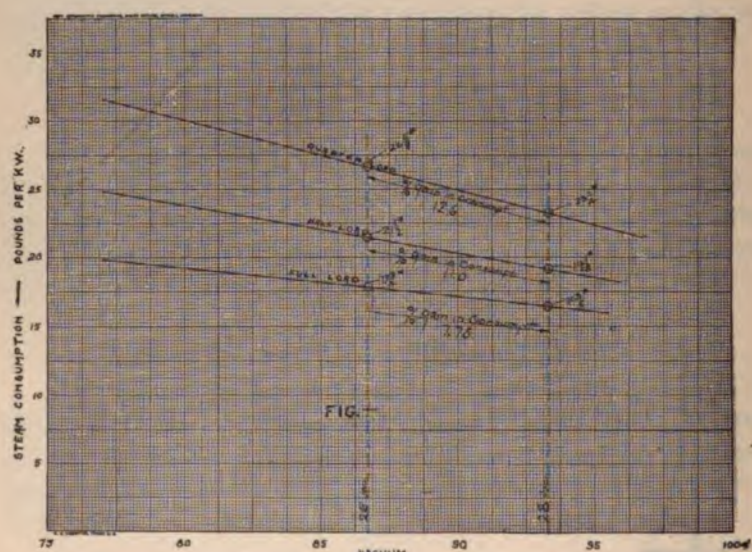

FIG. 3

ferent loads. These curves are from a test of a Brown-Boveri turbine.

The Hon. Chas. A. Parsons, in a paper before the Institute of Electrical Engineers of England, May, 1904, states that between 23-inch and 28-inch vacuum an increase of 1 inch in vacuum makes a difference in economy of 3 per cent in 100-kw units, 4 per cent in 500-kw units, and 5 per cent in 1500-kw units, and that the percentages increase more at high vacuums than at low.

From Mr. Bibbins' articles in *Power* of January, 1905, we have presumably the results of vacuum tests obtained at Pitts-

burg. At from 26-inch to 28-inch he shows an increased economy in steam of 6.7 per cent. He also shows at 26.5-inch a rate of increase per inch vacuum of 3.5 per cent, and at 28-inch of 5.5 per cent, which supplements and agrees with the figures given above of 6.7 per cent from 26-inch to 28-inch.

From a recent test made by your committee on a 2000-kw turbine, different vacua were run for the specific purpose of obtaining the vacuum effect; it was found that for this turbine running at 1800 kilowatts, the increase in economy is 5.2 per cent from 26-inch to 27-inch vacuum and 6.75 per cent from 27-inch to 28-inch.

Under the following assumed conditions the economy effected in operating under high vacuum would work out somewhat as follows:

Assumed size of unit	2,000	
Average load	1,500	
Hours run per day	15	
Hours run per year (300 days)	4,500	
Price coal per ton, 2,000 pounds	$3.00	
Evaporation	9 pounds	
Economy pounds water per kilowatt	22	
Rise in vacuum	26–28 inches	
Assumed per cent increase of economy due to increase of vacuum from 26–28 inches	6 per cent	
Water saved per kw-hour	1.32	
Water saved per year	140,000 cu. ft.	
Cost of water saved per year at 2.58	$35.00	$35.00
Coal saved per year	500 tons	
Cost of coal saved per year at $3.00	$1,500.00	1,500.00
Increased cost of condenser plant for 28-inch over that of 26-inch assumed $5,000.00; interest on above at 5 per cent, depreciation 10 per cent, other fixed charges, including repairs, 2 per cent, total 17 per cent		$1,535.00
	$850.00	850.00
Saving per year		$685.00
The above does not include the extra cost in steam to run the larger auxiliaries, but, inasmuch as such exhaust steam would return a benefit to the feed-water if they were all steam-driven, we will assume that the extra cost in water is 2 per cent of the total steam guaranteed by the turbine and will amount per year to	$12.00	12.00
Total net saving		$673.00
With interest at 5 per cent this represents a capital saving of		13,460.00

LEAKAGE OF AIR

An important feature of operation with high vacuum is the necessity of having air-tight stuffing boxes and pipe joints, lack of which results in loss of economy to the turbine and increased consumption of steam by the dry-vacuum pumps and circulating pumps. The committee suggests the following as some of the remedies:

All joints after being made up can profitably be gone over with any heavy homogeneous paint (this preferably should be done when working under vacuum), such as black asphaltum, or shellac and red lead, both of which dry readily. This is a simple remedy and when carefully applied is very effective. There often is considerable air brought into the feed water at pumps and open tanks, and it is desirable to work the water of condensation on a closed system, or, when an open system is used, to arrange that the water is as little stirred up as possible; liberation of entrained air might be assisted by the use of steam coils in the bottoms of tanks.

In pressure pipes when velocity of the water is slow it is possible to trap off considerable air by the use of a stand-pipe communicating with the feed pipe by a narrow slot and having at the top a float-actuated snifting valve.

Unless close supervision is used to see that lazy or indifferent engineers do not cover up the existence of air leak by pushing their air and circulating pumps at a greater speed and power than would be necessary with tight joints in exhaust piping, condensers and stuffing boxes, the operating costs can be very appreciably added to in a manner that often defies detection. Connections from turbine to condenser and condenser to pumps should be as short as possible, to avoid the chance for leaks and consequent uneconomical operation.

AIR COOLERS

Where a surface condenser is of the counter-current type an independent air cooler appears to be an unnecessary expense and care if the condenser cooling surface is of the proper amount. In the parallel-flow type, however, an air cooler is undoubtedly of considerable benefit in reducing the tension on the air and non-condensable vapors.

CHOKING THE CONDENSER

Many types of condensers are laid out with a solid bank of tubes presented to incoming steam. Naturally the steam has to seek its way between the tubes to get to the body of condenser, and in narrow condensers the net area between tubes of each layer may be even less than the area of exhaust pipes, and consequent velocity of the steam through these passages may mount into tens of thousands of feet per minute. The desire in a condenser should be that the incoming steam would immediately spread out over the whole cooling surface in its proportionate amount, otherwise only a limited area of surface will be devoted to the act of condensing and the remainder to cooling down condensed water.

Very good results have been obtained toward increasing the efficiency of condensers by opening channels between tubes equal in aggregate area to the exhaust pipe and extending somewhat beyond the centre of the tube nests. The benefits were manifested in an increased vacuum with the same amount of cooling water and a radical decrease in the tendency of the vacuum to drop under overloads. These channels also offer a greater entrance area into the body of the tubes, by way of the interstices between the tubes forming the sides of the channels.

ACCESSIBILITY TO THE INTERIORS OF CONDENSERS

It is recommended to members that on all new contracts they insist upon complete and adequate means of inspecting the ends of tubes and for obtaining admittance to the condenser above and below the tubes. All openings should be made to accommodate the entry of a man wherever possible. This detail is naturally one of operation in which we are especially concerned, as it has to do with our labor costs for repairs. It has the further economic value that any piece of apparatus that is easy to inspect is going to be maintained in a more efficient condition than one on which overhauling is a difficult matter.

ARRANGEMENT OF CONDENSER PLANT

Undoubtedly the best arrangement of the condensing plant is the use of a counter-current condenser placed as close to the exhaust nozzle as possible and with the dry-air pumps drawing from the condenser at the point of coolest circulating water; this pump also so placed that the minimum of pipe connection can be

used. With this arrangement the possibility of air leaks would be greatly reduced, the quantity of circulating water would also be lessened owing to the lower tension of the air which has just left the coldest tubes of the condenser. We believe that it is important in lowering operating costs that the above design of the installation should in all cases be followed as rigidly as individual conditions will permit.

HORIZONTAL AND VERTICAL SURFACE CONDENSERS

Condensers are usually built with horizontal tubes, but in some instances in Great Britain where the circulating water was very dirty they have been built vertically with the top water head open in order that the tubes may be cleaned while the condenser is in operation. This design is undoubtedly good for its special condition, but has the objection that in the case of the turbine operating high pressure and the circulating pump stopped, one-half of the tubes and their packing would be subjected to 212 degrees without any water to carry off the heat. It is also a well-established fact that a vertical tube does not transmit heat so readily as does a horizontal tube.

APPEARANCES

The general appearance of condensers would be greatly enhanced if the contractors would devote a little more time to the consideration of the ugliness of condensers in general. Such a detail as horizontal ribs on the exterior of the condensers could be easily eliminated, thus avoiding an unsightly catch-all for dirt, dust and grease. While this is more offensive to the eye in installations where the condenser is situated in the main operating room, yet it is no less a serious matter when placed under the floor in an obscure position.

In the matter of pumps, while those driven from motors are less objectionable from the point of appearances, yet the steam-driven units that many of us use can be vastly improved in the direction of their own appearance and any surrounding object that is within reach of their dirt. This is probably a matter that is largely dictated by the capacity of the owner's pocket-book, yet the amount of waste, oil and time that is uneconomically used in the operation of the open-type small engine would make up the extra cost of an enclosed engine before the plant had reached the point of replacement.

OIL IN TURBINE AUXILIARIES

This is in stationary engine practice a very much accepted defect in operation. Manifestly the oil from auxiliaries carried in exhaust steam will coat the tubes of the closed heater and will also be sufficient to make useless for feed water the condensation of the turbine if put into the condenser. As often happens in a plant where there are many steam auxiliaries, the amount of exhaust sometimes exceeds the requirements for heating feed water, and in such instances it would be very profitable to throw this exhaust to the condenser and obtain an increased efficiency on those auxiliaries. It would then appear to be wise to have the steam ends of such auxiliaries so designed that they can accept superheated steam without the assistance of oil. We beg to suggest, for the sake of discussion, that with piston-valve engines this might be attained by the use of plain plug piston valves without rings, and plug pistons also without rings. The decreased density of superheated steam should greatly decrease the proportionate leakage as compared to saturated steam, and the type of valve and piston permits of a very inexpensive renewal when worn. By making the stuffing boxes of a good length, so as to carry them well beyond the walls of the cylinder, trouble from overheating them should not be anticipated.

There is, of course, the alternative of using the ordinary type of steam cylinder and piston with the necessary amount of lubrication, and separating the oil from the exhaust steam before it enters the heater or condenser.

CARBONIZATION OF OIL IN DRY-AIR PUMPS

Considerable trouble has been reported from carbonization of the oil in the air cylinders. This has led in some instances to the use of a high grade of mineral oil especially produced for use in air compressors. There have also been reports that this has not cured the trouble. While the temperature in the cylinder does not rise to an excessive amount, yet if a temperature could be maintained below a possible critical point this trouble might be eliminated. The simplest way to do this would seem to be to jacket with cold water the valve casing and covering over which the hottest air, that of compression, is continually sweeping. The metal surrounding the ports in the cylinders is perhaps the greatest accu-

mulator of heat, and if these port passages were cast with walls no thicker than necessary, further supplemented by cooling water, the trouble would be minimized. An inter-cooler between cylinders of a two-stage pump would also be of very considerable benefit both as to decreasing carbonization and as to increasing the efficiency of the air pump; the remedy used by one correspondent, where he boiled out the air cylinder once in two weeks' time with caustic soda, was very aptly called by himself, "a nuisance."

ATMOSPHERIC RELIEF VALVES

Atmospheric relief valves are undoubtedly to blame for some of the air leakage into the condensers. Where the vacuum is of so great importance, as in turbine work, it will undoubtedly pay to go to further refinements in the design of these valves in the endeavor to secure automatically absolute tightness. It is common practice to use a water seal on these valves, but there is seldom provision made to insure that it is always maintained. It may either be no seal at all or the exhaust pipe full of water. It should be possible, now that the use of oil has been done away with by the turbine, to replace the present brass seats on valve body and disc with hard rubber.

Rubber would be flexible enough to take up any inequalities in the seats due to machining or to distortion from heat and the strains of the large exhaust piping.

The usual present design of relief valve does not allow of ready inspection, thereby offering but another excuse for the engineer to "let her go" until he cannot escape criticism from even the most obtuse layman.

CIRCULATING PUMP FOOT VALVES

Some stations have reported that they have had trouble with foot valves for circulating pumps. When proper priming arrangements have been installed it would seem that foot valves are unnecessary. A good steam air ejector or a connection to the condenser, when there is a dry-air pump, is amply sufficient to raise the water to the pump runner in installations where the suction lift is not greater than 24 feet. It is also generally true that clearing the foot valves where the water is dirty consumes the greater part of the time taken in starting up.

DEFECTS IN CONSTRUCTION AND ERECTION

We have reports of condenser tubes leaking at the ferrule shortly after the condenser has been installed. This can, of course, usually be traced to the lack of care on the part of the maker, and presumably he has in most instances repaired the damage. He never, however, assumes the total costs such as are due to delay and loss of interest on the whole idle investment. Supervision in the matter of condenser and pump erection can not be too rigid, as, after starting, a good many leaks and defects of various kinds may be covered up and become customary conditions with the operating force; whereas, if the turbine auxiliaries were started with all conditions right, any falling off of efficiency without attending to same would be inexcusable. It naturally follows, also, from the above, that the various auxiliaries might be doing considerably more work than there was any necessity for.

AMOUNT OF COOLING WATER

As there seems to be considerable divergency in the matter of cooling water supply for condensers operating under the same conditions, it may be well to go over the very simple theory involved.

Total heat of steam at 28-inch $= 1112.4$

With cooling water at 70 degrees and condensed water at 100 degrees it is possible for the cooling water on leaving the condenser to have gained 30 degrees of heat.

$1112 - 68 = 1044$ B.t.u. heat lost by the steam per pound.

$1044 \div 30 = 34.8$ Ratio of circulating water to condensed steam, assuming that cooling water took up all of the heat in the steam in reducing it to water and left the condenser at the temperature of the vacuum. In actual practice, however, the cooling water usually leaves the condenser at a temperature fully 10 degrees in counter-current condensers and 17 degrees in co-current condensers lower than that of the vacuum. To show the effect of the above:

$30^\circ - 10^\circ = 20^\circ$ Rise in temperature of the circulating water.

$1044 \div 20 = 52.2$ Ratio of cooling water to condensed water in counter-current condensers.

$30 - 17 = 13$ and $1044 \div 13 = 80$ Ratio of circulating water to condensed water in co-current condensers.

This shows the relative efficiency of the counter-current and

co-current surface condenser and also how much the condenser question is purely one of temperature. Also take the case of water during the winter season and assume a temperature of 40 degrees for the cooling water.

$100^\circ - 40^\circ = 60^\circ$

$60^\circ - 10^\circ = 50^\circ$ possible gain in temperature of cooling water in counter-current condenser.

$1044 \div 50 = 20.9$ times the amount of condensed water for cooling water.

In actual practice for temperatures of cooling water ranging from 60 to 70 degrees circulating pumps have been installed for volumes of cooling water ranging from 40 to 70 times that of the condensed water. At the low ratio of 40 to 1 the cooling water temperature must be close to 60 degrees for so high a vacuum as 27.5-inch, and even then considerable difficulty is experienced in maintaining the 27.5 inches unless the ratio of cooling surface to pounds of steam condensed is 1 to 8 or better.

From the above, thermometers on circulating inlet and discharge are recommended as valuable detectors of air leaks in the condenser and piping.

CAPACITY OF DRY-AIR PUMPS

From the experience obtained in their own plants and in testing others, the committee recommends that the capacity in cubic feet of volume swept by the air piston of the dry-air pump be not less than 45 times the volume of the condensed steam, and where overload conditions are frequent not less than 50 times the water volume.

SIZES OF CONDENSERS AND AUXILIARIES

The turbine installations concerning which we have received information where 28 inches of vacuum is maintained with a cooling-water temperature of 70 degrees Fahrenheit show a minimum ratio of cooling surface in the condenser to steam condensed of 6.9 square feet per pound. But the more usual ratio, even where the cooling water is 5 to 10 degrees lower in temperature, is 8 to 9 square feet per pound. In the first instance noted above it is to be remarked that the ratio of circulating water to condensed water is 70 to 1; with greater cooling surface ratios the proportion of cooling water is reduced.

STEAM USED BY AUXILIARIES

These figures are obtained from letters sent to us by turbine owners:

3 200-kw De Laval exhausting into one condenser.

3000 gallons per minute circulating pump; 2-stage dry-vacuum pumps 8 x 12 x 12-16; duplex wet-vacuum pump; 15-kw turbine exciter. Steam by auxiliaries, 2.6 pounds per kilowatt.

Byllesby & Co.:

Steam per kilowatt at half load, 3.5 pounds.

BOSTON EDISON COMPANY

5000-Kw Turbine Unit

Kilowatts on turbine	2,713	3,410	4,758
Vacuum	28.4	28.7	28.6
Barometer	29.53	29.95	29.96
Boiler-feed pump, I-hp	13.9	23.7	27.4
Circulating pump, I-hp	69.1	69.1	69.1
Dry-vacuum pump, I-hp	24.3	23.2	23.8
Step-bearing pump, I-hp	6.4	5.8	5.6
Wet-vacuum pump e.hp	8.6	9.2	9.8
Total power for auxiliaries	122.3	131.	135.7
Per cent of power of auxiliaries to power of turbine	3.4	2.9	2.1
Per cent of water used by auxiliaries to that used by turbine	8.4	7.4	5.7

TEST REPORTED BY NASHUA LIGHT, HEAT AND POWER COMPANY

500-Kw Curtis, Rated Water per Hour 20.5 Pounds

	Steam per hour saturated	Steam per hour superheat	Pounds difference per hour	1 per cent difference	Degrees superheat	
Accumulator pump	130.9	130.9	....	....	....	
Dry-air pump	181.58	183.13	....	....	....	
Boiler-feed pump	352.15	249.58	102.57	29.12	71.98	Feed pumps act as wet vacuum pumps
Westinghouse jun. driving circ. pumps	663.64	439.36	224.28	33.79	97.65	
Totals	1,328.27	1,002.97				

Per cent of rated water consumption of turbines at full load .... 12.9 per cent 9.78 per cent

Dry-air pump, 6-inch by 12-inch /12 93 r.p.m.

Boiler-feed pumps, $\frac{7.5 \times 4.5}{\text{10-inch}}$ 9.8 r.p.m.

Centrifugal pump engine, 7-inch by 6-inch.

It is, however, a question whether the extra cost of steam for driving larger auxiliaries for high vacuum work is of any great moment, as such steam is of considerable value in the feed heater.

It is to be noted also that these figures are for total consumption of auxiliaries and that the increase of steam necessary to obtain two inches more than 26 or 28 inches must necessarily be very small.

There has recently been introduced in this country a condenser using corrugated plates instead of tubes in the condensing vessel, known as Ljungstrom. The claims made for this condenser are that it occupies less space, weighs less, is built in a sectional form, and can be more readily inspected and repaired.

As to its relative merits, the committee has been unable to examine any condenser of this type. Of course, perhaps, it is needless to mention that this would not change any surface condensing plant so far as auxiliary apparatus is concerned.

Test on 1000-Kw Turbine at the Plant of the Hartford Electric Light Company, Hartford, Conn., on April 6, 1905:

TURBINE

This turbine is a 1000-kw Parsons type of turbine, built by the Westinghouse Machine Company, Pittsburg, Pa., and runs at 1800 revolutions per minute. The generator is a 60-cycle, 2-phase, 2400-volt alternator, built by the Westinghouse Electric Company.

CONDENSER

The condenser was built by the Alberger Condenser Company, with 6000 square feet of cooling surface, and is of the counter-current type 3-pass, with steam entering at the bottom and the condensed water taken from a hot well cast in the bottom of the condenser and with dry-air pump suction taken from the top of the condenser. This condenser, with its dry-air pump and circulating pump, is intended to handle the exhaust steam from two turbines of the size noted above.

CIRCULATING PUMP

Built by the Alberger Company, and is a 14-inch vertical-axis centrifugal pump driven by a vertical Westinghouse type "C" constant-speed induction motor running at 580 r.p.m. and rated at 50 horse-power.

DRY-AIR PUMP

An Alberger 2-stage pump with cylinders 8, 18, 18 and 24-inch stroke.

WET-AIR PUMP

Also built by the Alberger Company, and is a horizontal duplex pump 6-inch by 5.5-inch by 6-inch, with 4-inch suction and 3-inch discharge.

LOCATION OF AUXILIARIES

The exhaust from the turbine is taken out of the bottom of the low pressure and runs down vertically to a lead which brings the exhaust horizontally into the bottom of the condenser. The dry-air pump is situated directly above the condenser, with as short a connection as possible to the pump. There is no air cooler on the dry-air suction, as the air is taken out of the coldest part of the condenser. The wet-vacuum pump is situated alongside of the condenser immediately below it, and connected to the hot well with a short run of pipe.

OPERATION OF TURBINE

Throughout the time of test the turbine operated very quietly and without, to our minds, any appreciable vibration through all the loads, from no load to 50 per cent overload. The operating engineer devoted the principal portion of his time to the attention of the auxiliaries. We endeavored to impress upon the Hartford Electric Light Company that our test of this turbine was to be done under strictly normal conditions of running.

In this station, from the statements of the operating people, we find they usually take anywhere from 20 minutes to half an hour to put the turbine into load, and that they seem to think it good policy on their part always to take this time. The Westinghouse representatives claim that a good average time under operating condition should be 15 minutes, and that they have in an emergency got the turbine in in seven minutes.

OPERATION OF AUXILIARIES

The auxiliaries for the turbine in this plant require the principal attention of the one engineer, the wet-vacuum pump requiring attention in starting up, in order that same may not become air-bound. During the running of the turbine the dry-air pump has to be watched at very high vacuums on account of apparently indifferent regulation at those points. In this connection, however, it must be remembered that this one dry-air pump is intended to

take care of two turbines of this size. The station people report that they have considerable trouble with carbonization of oil in their second-stage cylinder of the dry-air pump, to the extent of partially closing air ports into the cylinder and making the air relief valves stick open.

LOADS

The loads on the turbine at all times were purely commercial in the respect that the current generated was used for lighting and motor driving. We were favored as regards steadiness of load at this plant by the fact that while we were testing, all the current generated for this company, with the exception of this station, was done by two water-power plants working in parallel with this station and governed by a Lombard governor.

The condenser was tested for leakage and found to be absolutely tight. There were two leakage tests—one before beginning our test and one after. The steam gauges were tested as warm as possible several times through the test. The thermometers were compared and calibrated before the beginning of the test and after the same.

TESTING APPARATUS

The electrical testing apparatus consisted of two wattmeters and two voltmeters, one set on each phase, with their respective transformers. These instruments were brought from New York in the hands of the assistants on the test, and after returning to New York from Hartford they and their transformers were sent to the Electrical Testing Laboratories of this city for calibration. The calibrations have been applied to the readings for kilowatts.

The steam apparatus consisted of carefully standardized thermometers placed in the steam chest in front of the admission valve and in the exhaust pipe on the horizontal leg leading to the condenser. There were also steam gauges on the steam pipe close to the turbine and on the first stage of the turbine, and a mercury column on the exhaust nozzle close to the turbine casing. Barometric readings were obtained from the Weather Bureau at Hartford and corrected for the level of the station, and the corrected readings applied to the readings of the mercury column to give us our absolute pressure.

Water-weighing apparatus consisted of two weigh tanks on two platform scales with a receiving tank below. The water was led to these tanks with valves so placed that it could be directed at

will to either one tank or the other. Standard test weights were obtained in the city of Hartford, and the scales tested and found to be correct.

TESTS—DURATION AND NUMBER

In all, eleven tests were run, of which nine, including the leakage test, were reported to you. It was the desire of the Hartford Electric Light Company that all tests that we should make be made within one twenty-four hours. This was accomplished with the eleven tests spoken of above, but, owing to the limited time, we were prevented from making any further extended tests. The conditions in this plant were such that variations at will of the superheat could not be made, and you will notice, from the records of the test, that the superheat followed the line of load, as also did the vacuum and steam pressure. This quality in the steam pressure and superheat is due to the fact that there were only two boilers in the plant, and they were connected directly with the superheaters and in such a manner that they could not be by-passed in order to mix saturated steam with the superheated steam.

Each test was of one hour's duration, with the exception of the no-load test, which was half an hour. This turbine at the time of the test had not as yet been covered with non-conducting material, although the middle lagging was in place about the turbine.

TABLES AND CURVES

The tables and curves contain the data from the test. Table No. 2 contains the actual figures obtained, corrected for the calibration of the various instruments used on the test.

In Figure 4 the total water curve and water per kilowatt-hour are shown. It was impossible, owing to the lack of evidence from the tests, to make any correction of these curves for the variations in superheat, vacuum and steam pressure. We are also, for the same reason, unable to furnish you with curves showing the effect of increase of vacuum and superheat.

We wish to thank, through this medium, Mr. Rollins of the Hartford Company, who very kindly gave us the privilege of running this test at a time when he had sufficient water power for all electrical purposes in his water-power stations.

During the running of our tests Mr. Hodgkinson of

the Westinghouse Company was present for a portion of the afternoon, and examined our apparatus and our methods, pro-

Test of 1000 Kilo-Watt Westinghouse-Parsons Turbine.
Hartford Ct.

April 6, 1905.

Time.	Kilo-Watts Corrected	Superheat	Absolute Pressure Inches	Lbs. Water per Hour Gross	Water Seal of End Bearing	Steam fr. By Pass Valve Chest	Net Water Lbs. per Hour	Water per K.W. Hr.	Steam Pressure Throttle Corrected
8^{45} & 9^{45} PM	1546.4	108.0	2.19	30172	939	114.5	29347.5	18.98	135.0
6^{45}-7^{45} "	1219.3	92.4	1.70	23933	852	106.5	231875	19.02	137.1
8^{30}-9^{30} AM	1047.6	76.0	1.37	20900	796.5	68.	20171.5	19.26	137.2
2^{30}-3^{30} PM	1071.5	77.7	1.70	21281	765.	75.	20591.	19.22	137.7
10^{45}-11^{45} AM	735.8	72.9	1.21	16000	829.5	43.5	15214.	20.68	138.6
12^{45}-1^{45} PM	463.0	62.1	1.01	11559	911.	23	10671.	23.04	140.7
1^{30}-2^{30} "	271.8	49.2	0.88	8968	951.	19	8036.	29.56	146.3
9^{30}-9^{50} "	0	24.5	1.43	3596	912	0.	2684.		144.7

TABLE I

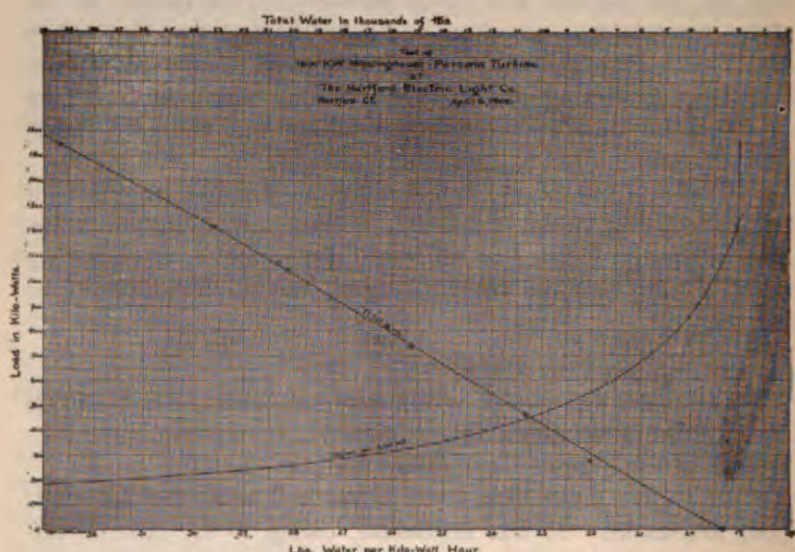

FIG. 4

nouncing himself as being satisfied with the same before he left.

(Signed) CHAS. H. PARKER,
WALTER GOODENOUGH.

The committee has conducted a number of other tests, which it was hoped to present with this report; there was, however, some question raised as to the accuracy of the instruments used,

and in view of this circumstance the committee has considered it undesirable to publish the results at this time.

It should be stated also that the committee had expected to conduct other tests on turbines of the same type as the one on which the above-mentioned tests were conducted, but the necessary apparatus was not placed at its disposal in time.

This year your committee held a larger number of meetings and has endeavored to cover in detail the operation of turbines in the users' stations; the principal work of the committee being subdivided among the members. Mr. Moultrop gave special attention to the correspondence with users of steam turbines, and Mr. Andrew conducted the investigations on condensers and auxiliaries.

The committee appointed Mr. Chas. H. Parker, of Boston, and Mr. Walter Goodenough, of New York, as engineers of tests to conduct the tests for the committee, and we wish to express our appreciation of the very thorough and careful manner in which the work has been done by these gentlemen.

The committee desires to extend its thanks to the members for uniform courtesy in supplying information in detail on the operation of their turbines and auxiliaries; also to the manufacturers for their assistance and the liberal spirit in which they have discussed the various questions brought to their attention.

We also desire to express our thanks to the British manufacturers and firms operating turbine auxiliaries, and especially to the firm of Messrs. Mirrlees, Watson and Company, who have placed at our disposal data on 14 turbine plants with which they have been identified.

We recommend to the association the appointment and continuation of a committee on steam turbines, so that further information may be placed at the disposal of members of the association, and we believe that the association through its committee may be of material assistance in standardizing the units and in encouraging improved efficiency.

Respectfully submitted,

Committee,
W. C. L. Eglin, Chairman,
A. C. Dunham,
I. E. Moultrop,
Geo. W. Cato,
J. D. Andrew.

Mr. Williams: Mr. President, at this time I should like to propose a resolution of thanks to this committee and to incorporate in that resolution a recommendation that this committee, which has done such important work, be continued.

(The motion was seconded and carried.)

The President: We will now have the paper on *Operating Features of Vertical Curtis Steam Turbines,* by Mr. A. H. Kruesi, of Schenectady.

The following paper was presented by Mr. Kruesi:

OPERATING FEATURES OF VERTICAL CURTIS STEAM TURBINES

Balance

The very considerable experience already had with turbines has fully demonstrated the claim that they require far less attention and adjustment than do reciprocating engines to insure continuous and uninterrupted service. As a consequence of their high speeds, however, the centrifugal forces acting on the rotating parts are of far greater magnitude than those which occur in reciprocating engine units, and one of the important features of successful operation of turbine-driven units is the maintenance of a good running balance.

The first essential for good running balance is a good alignment of the top bearing with respect to the shaft. This can be readily determined by removing the top bearing and shifting the top bearing shield of the generator if necessary. Adjusting devices are provided for this purpose. The shaft should run true and the bearing shield should be concentric so that the maximum eccentricity will not exceed from .002 to .004 inch in turbines from 500 to 5000-kilowatt capacity, respectively. It is comparatively easy to secure such freedom from vibration in all sizes of turbines that a one-cent piece will stand on edge at the top of the machine indefinitely, and after having been brought to this condition when first started the machine will require little further attention on this account. A liberal flow of oil through the bearings is desirable both for its cushioning effect and for the sake of lubrication. The balance cannot be considered final until after the machine has been thoroughly heated and remains unchanged. The balance being good, there is practically no load on the guide bearings and consequently practically no wear. Although it is important that the alignment be good, close clearance in the bearings is not necessary provided the lubrication be ample.

Bearings and Lubrication

The generator bearings require the same attention as would be given to ordinary dynamo bearings. The middle bearing, on

account of heat conduction through the shaft from the turbine, runs warm, but with perfect satisfaction because of the light loads imposed on it by the vertical shaft.

The oil is fed to a reservoir with sight-feed glasses mounted at the top of the generator and also provided with an overflow pipe to the drain. To insure a full reservoir the supply is adjusted to cause a slight overflow. From the sight-feed glasses independent pipes supply oil to the two upper bearings under a sufficient gravity head to insure perfect lubrication under all circumstances.

The quantity of oil required for the top and middle bearings of turbines of various sizes is given in the following table:

AMOUNT OF LUBRICATION REQUIRED BY BEARINGS

Upper Bearings			Step Bearings			
Kilowatts	Speed	Gallons Oil per Minute	Step Press.	Baffle Press.	Pump Press.	Gallons per Minute
500	1800	.38	180	45	225	1.0
800	1500	.38	180	45	225	1.5
1000	1200	.50	380	95	475	3.4
1500	900	.50	392	100	490	3.4
2000	750	.50	420	105	525	3.4
3000	600	.75	520	130	650	3.4
5000	500	.75	640	160	800	6.0

This oil flow includes a reasonable amount of overflow and requires a continuous oiling system, generally comprising a pair of steam-driven duplex oil pumps, a drain tank, and an overhead gravity tank, supplied with the turbines. The tanks are designed so that the oil contained in the pipe system can not cause flooding and so that the steam-driven pumps may always be run at such a speed as to keep the upper tank always filled, the surplus oil returning through an overflow. The tanks contain strainers, but are not filters, and a separate filter, connected in series with the return pipe from the upper bearings, is always desirable. The oil in its passage through the bearings is not exposed directly to the air, but a gradual discoloration and collection of grit is inevitable.

Step Bearing

To eliminate the packing at the lower end of the shaft, the step bearing is generally water-lubricated, the shaft being fitted with a bronze sleeve running in a babbitt-lined guide bearing. With water lubrication no attention is required beyond running the pressure pump, which may supply one or a number of turbines, the division of the water being automatically cared for by the baffler, the purpose of which is to make turbines of the same size or different sizes take their proportional share of the total flow of lubricant supplied by the pumps. This baffler is supplied with every vertical steam turbine and is a fluid friction device of simple construction and readily adjustable to give any pressure drop desired. By its use it is possible to operate turbines of 500-kilowatt and 5000-kilowatt output from the same pumps and piping system economically and satisfactorily under every condition.

The water used for the lubrication of the step bearing and guide bearing is ordinarily permitted to flow over into the condenser and so on to the hot-well and feed-water tank, from which water is again taken for the step-bearing pumps so that the operation of the step bearing neither adds water to the boiler-feed system nor subtracts it therefrom. If more convenient, it may, of course, be taken from any other source. In any case it will be seen from the table above that the water so used is only a small percentage of the total amount required for the turbine at full load and will generally be less than the amount of "make-up" required. When running non-condensing it may be drained direct from the step bearing if desirable.

Since the bafflers used in series with each step bearing are designed to give a large drop in pressure (about 25 per cent of the step-bearing pressure) there is no object in reducing the pressure drop in the piping, which may be proportioned for a velocity of 500 feet per minute, and will never require larger mains than 1.5-inch pipe, extra heavy galvanized iron. The branches to turbines should be .75 inch to have sufficient strength, independent of the pressure they carry.

The step bearing is usually supplied with lubricant under the requisite pressure by duplex double-acting steam pumps of standard pattern, and generally each of sufficient size to supply all the turbines in the station. This mode of supply and the step

bearing itself have proven entirely satisfactory and reliable. No machine involving such speeds and weights as are encountered in steam turbines can depend on natural lubrication. The step bearing, however, has shown remarkable sturdiness when subjected to cessation of forced lubrication. To illustrate this a test has been made in which a 500-kilowatt turbine was run up to speed, lubricant and steam turned off simultaneously, the turbine brought to rest, due to the friction of the step, and immediately restarted, six times in succession without difficulty of any kind. After raising the step by means of the adjusting screw to compensate for the wear of the plates, they were just as good for further service as at the beginning, although naturally somewhat grooved.

Valves and Governor

The needle valves, or controlling valves, by means of which each of the main valves is opened or closed, as has been repeatedly described, require in some of the earlier machines occasional regrinding when the main valves open slowly. This difficulty has since been overcome by experiment and the selection of more suitable materials for the service, and by the use of steam chests of cast steel to avoid warping under the influence of highly superheated steam. With a view to still better operation, various forms of mechanically and hydraulically-operated valves are under test in service conditions. The mechanically-operated valves derive their motion from the turbine shaft under a fixed period, depending upon the turbine speed, and therefore have no tendency to accumulate changes in speed or to cause hunting. The governor controls the number of valves to be opened or closed by a modified Corliss release mechanism. The hydraulically-operated valves are positively opened and closed by a cam shaft under the control of a hydraulic cylinder, the piston of which connects with a follow-up attachment, which makes it absolutely non-hunting. The type of valve mechanism that will ultimately prevail as the simplest and most satisfactory can only be determined by practical experience, which is now being had in turbines under various conditions. It is desirable that the valve casings be drained to the casing of the turbine to avoid pocketing of water when the machine is at rest, so that it can be started and the load quickly applied in case of need.

The governor may readily be set for any desired speed and

degree of regulation within reasonable limits by simple adjustment of the tension and characteristic of its spring. It is customarily set for two per cent regulation between no-load and full load. Engines which regulate within two per cent are, however, seldom met with. The very large fly-wheel effect of the turbine generally enables it to exert a steadying influence on the whole system.

Clearance

The amount of clearance given between stationary and revolving parts has been fixed by extensive experience and is made sufficient to satisfy the most exacting practical requirements. For example, instantaneous loads have often been applied to a 2000-kilowatt turbine, by means of an oil switch, amounting to 50 per cent overload, both condensing and non-condensing, and instantaneous loads of from 7500 to 8000 kilowatts have been thrown off and on a 5000-kilowatt machine repeatedly with perfect freedom.

The rapidity with which the machine may be started up is not in any way limited by the clearance of the machine and is only controlled by the speed with which the steam piping may be warmed up. This depends upon the judgment of the engineer, and no fixed time can be set. It will generally be found that the auxiliary engines and other apparatus determine the time. This is especially the case where superheaters are used, it being necessary to use some caution in opening valves to avoid heavy doses of water previously condensed in the superheater tubes, steam pipes, and so forth. Such accumulations of water are always possible in steam headers and pipes having dead ends or sluggish circulation, and point to the need of separators for engine-driven auxiliaries and just as careful means for draining piping for superheated steam as would be provided if superheaters were not used. Sudden doses of water have sometimes caused damage to the auxiliary apparatus in turbine stations, but have never caused trouble to the turbine proper except when water came in such large quantities as to prevent the flowing of steam and thus momentarily slowed the machine down. As a rough guide it may be stated that 500-kilowatt machines have been started up from a cold condition, synchronized, and made to carry

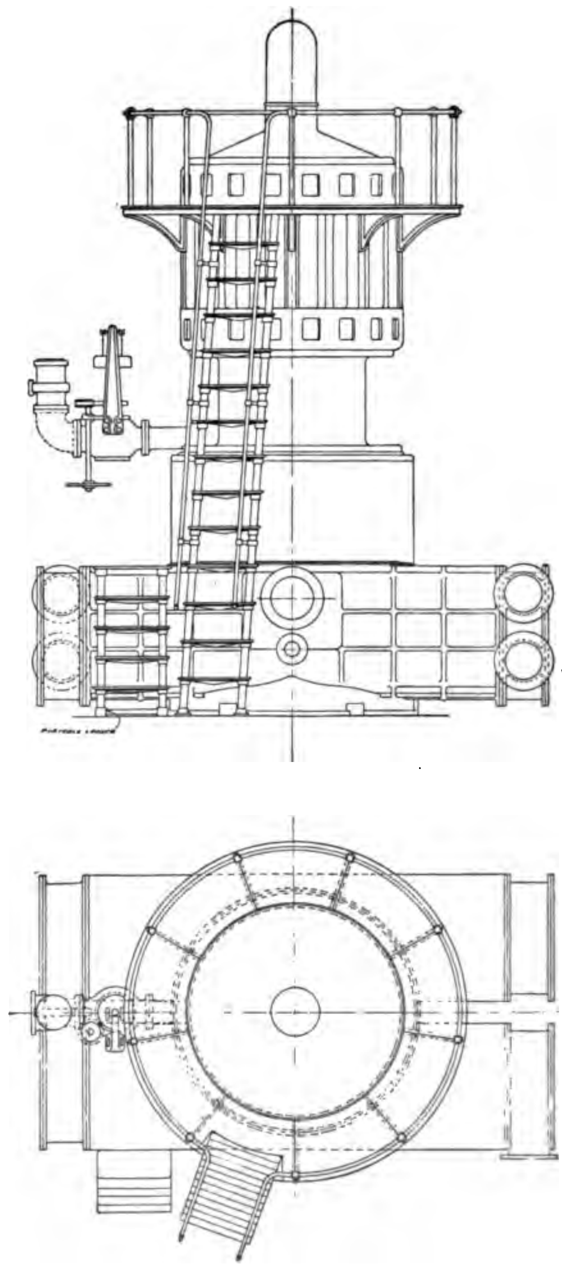

FIG. 1—OUTLINE OF 800-KILOWATT, 1500-R.P.M. TURBINE WITH CONDENSER BASE

load, in six minutes' time. Certain 1500-kilowatt machines have frequently been started, synchronized, and made to carry load, in three minutes. It is in general desirable to start up the turbines condensing—that is, with the circulating water in flow and the air pump running so as to have a vacuum while the turbine is being brought up to speed—as the amount of steam and the time of acceleration are thereby very much reduced.

Auxiliaries

The multi-stage construction of the turbine affords the facility, which has been made use of in some cases, for abstracting steam after being partly expanded, for feed-water heating and other similar purposes. The steam thus expanded in the turbine is more economically used by the turbine than by most types of engine-driven auxiliary apparatus and so offers an economical means for making use of electrically-driven auxiliaries, which are generally more desirable, on account of less cost for attendance and maintenance without the disadvantage usually incidental to electrically-driven auxiliaries—namely, insufficiently heated feed water. It is possible to build small turbines of the Curtis type which will yield exhaust steam for feed heating even more economically (for the reason that the pressure in the main turbine varies with the load), and such machines are frequently employed as exciters. Their simplicity and reliability, combined with the absence of lubricating oil in the exhaust, making it possible to use open-feed heaters and waste no water, will no doubt create a demand that will justify their development for driving centrifugal circulating pumps, hot-well pumps, feed pumps, and so forth. Means are at hand for simply and automatically varying the speed of such turbine-driven pumps according to the load on the main turbine.

Condenser Bases

Condenser bases of the general type illustrated in Figure 1 have been designed for all sizes of turbine from 500-kilowatt to 5000-kilowatt, and several have been in successful operation for some time past in connection with 2000 and 5000-kilowatt machines. The 500-kilowatt size has a cooling surface of 1800 square feet, the larger sizes four square feet of surface per kilowatt; all with four passes. While no direct comparisons have

thus far been possible, the indications are that this arrangement gives a better vacuum under given conditions than the separate condenser, as would naturally be expected from the shorter and more direct path of the steam and larger exposed area of tubes directly under the last wheel.

The condenser base effects some saving in floor space,

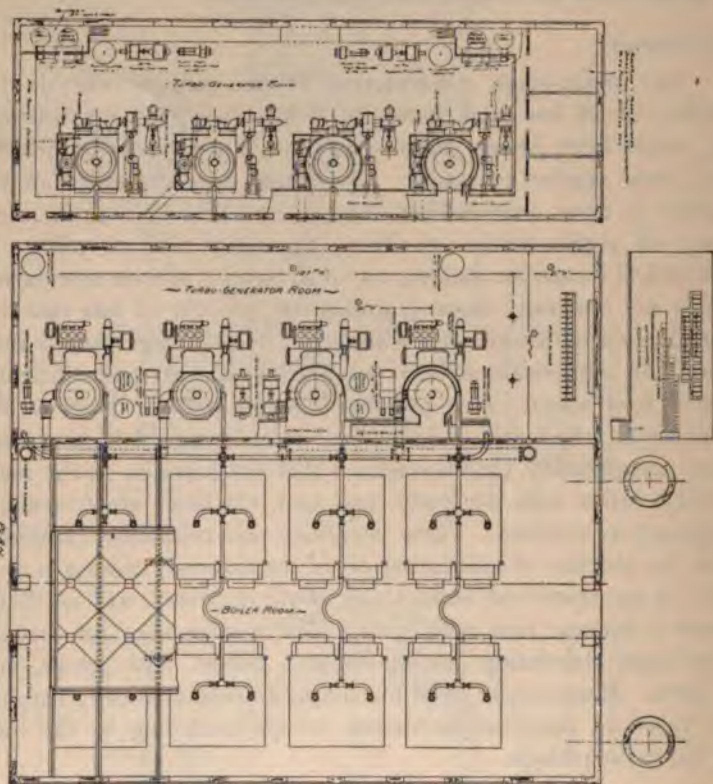

FIG. 2—COMPARATIVE PLANS, 2000-KILOWATT TURBINES WITH CONDENSER BASES AND WITH SEPARATE CONDENSERS

although, as Figure 2 shows, this is generally determined in a large measure by the type of auxiliary apparatus employed, and gives a more convenient relation of gallery and floor levels, eliminating the basement and in this way tending to reduce the attendance required. The cost of a turbine with condenser base is substantially the same as that of a turbine together with a separate

condenser. Any type of auxiliary apparatus may be used with the base condenser, and the auxiliaries will cost about the same in either case.

Low-Pressure and High-Pressure Turbines

A number of turbines are now under construction, designed to work at an initial steam pressure of 15 pounds absolute, and expanding to the best vacuum obtainable, taking steam at this initial pressure from the exhaust of reciprocating engines in plants already built, but operating non-condensing. The energy available between these pressure limits is approximately equal to that due to the drop in pressure in the engines, and the turbine may be expected with a 27-inch vacuum to develop a kilowatt-hour for about 42 pounds of steam, so that the output of the engines will be equalled and the station capacity and output doubled, if low-pressure turbines are installed of the same rated capacity as the engines, without adding to the equipment of boilers, high-pressure steam piping, and so forth, and without increasing the coal consumption. The turbines receive only what steam is exhausted by the engines, and their output will therefore vary in the same degree as the load on the engines, the turbines floating on the system and contributing as much power to the total station output as the amount of steam supplied by the engines makes available. The amount of steam taken from the boilers is then controlled solely by the cut-off of the reciprocating engines. Since the no-load steam consumption of the turbines will be less than that of engines of the same output, the turbines will never be a drag on the engines.

Turbines operating at the other extreme of the steam-expansion curve are also under consideration, taking steam at, say, 250 pounds pressure and expanding it to 110 pounds pressure, after which the steam is used for pulp digesters and other heating purposes. Since the whole of the latent heat of the steam is recovered by such a process, and as it would be nearly all lost if exhausted into a condenser in the ordinary way, such operation is very economical, the electrical output of the turbine being obtained by an altogether insignificant addition to the coal consumption that would be required for heating alone. The amount of energy made available per pound of steam through this range in pressures is relatively small, but can be economically made

use of in the type of turbine under discussion, and by a machine of reasonable size, because of the small volume and high density of the steam. For the same reason the number of turbine parts is small, and while the exhaust pressure, and therefore the shell pressure, is very high, all difficulty on account of shaft packing is completely eliminated by a modification of the water step bearing already referred to above.

Steam Piping

To conform with prevailing practice based on steam-engine experience, the steam pipes for Curtis turbines have been proportioned for a steam velocity of about 6000 feet per minute at full load, non-condensing. Economy, both in capital cost and in operation, however, makes small piping desirable, and there are a number of reasons why the whole of the steam piping for turbine stations should be designed on a different basis. The low velocity mentioned is probably well suited to engine work, to avoid vibration of the piping due to the pulsations in flow of the steam, which do not exist in the case of the turbine, and to hold the pressure drop within the economical limit imposed by the engine and give the full pressure up to the point of cut-off. The turbine, on the other hand, takes steam continuously, and the maximum flow is the same as the average. A reduction in pressure below that for which the engine cylinder and cut-off dimensions are designed causes a larger increase in steam consumption than in the case of the turbine, whose mode of operation makes it more flexible in this respect. An increase in the pressure drop allowed between boiler and turbine is even more justifiable when the steam is superheated, in order to reduce radiation losses, and involves no increase in initial cost, boilers costing substantially the same whether built for 150 pounds or 200 pounds. The mere increase in pressure from 150 pounds to 175 pounds by gauge reduces the volume by 12 per cent and permits a six per cent reduction in the diameter of pipes. It therefore seems desirable to make the rated boiler or safety-valve pressure about 25 pounds higher than the rated turbine pressure and permit a certain variation in pressure under extreme conditions, and correspondingly less for normal load, and so forth, thereby reducing the size of the pipes and fittings and materially reducing the cost of the piping, securing drier steam, avoiding the frequent blowing of pop-valves; and

incidentally another important advantage—namely, less trouble from leaky steam joints, especially when superheated steam is used. It is sometimes found that the only satisfactory joints in turbine plants are those on the turbine itself, pointing to the need of heavier flanges and bolts. The dimensions of the turbine flanges* have been proved satisfactory by years of experience, and are therefore given here in Figure 3 and Tables II and III. Leaky joints on fittings are probably sometimes due to the warping of cast iron on account of its want of elasticity and extreme expansion under superheated steam. Valve bodies of steel castings and valve seats of nickel bronze† are unquestionably superior for such work.

Much of the difficulty with pipe joints is no doubt due to insufficient elasticity and provision for expansion, and this can be largely overcome by the use of the smaller piping here advocated, by reason of the fact that the flanges and bolts of small pipes are relatively stronger than those of the larger sizes and because flanges on small pipes are subjected to smaller forces tending to spring them and open the joints, for the reason that the forces set up in the pipe bends, used to afford flexibility, are relatively much smaller for the smaller sizes of pipe.

The expansion of the pipes is inevitable, and is the same regardless of the size of pipe, but the force brought to bear on the flanges and fittings of a six-inch pipe will be about four times as great as those for a four-inch pipe, and two and one-half times as great for a 12-inch pipe as for a nine-inch pipe. An example may be of interest: Figure 2 shows four 450-horse-power boilers connected in the most direct manner to a 2000-kilowatt turbine. We may consider that the boilers would ordinarily have six-inch nozzles, that eight-inch pipe would be used to carry the steam from two boilers, enlarging to 10-inch to carry that for the four boilers, uniting with a 12-inch header and continuing 10 inches in diameter to the turbine. As an extreme case these may be com-

* Designed by W. A. Pearson.

† Approximate composition, copper 77; tin 10; zinc 4; nickel 9.

pared with pipes four-inch, five-inch, seven-inch, nine-inch and seven-inch, respectively, as follows:

	Low Velocity	High Velocity
Nominal sizes of pipes, extra heavy..........	6, 8, 10 12, 10	4, 5, 7, 9, 7
Velocity in pipes to turbine at normal rating of boilers, saturated steam 175 pounds gauge pressure..................................	3000 3400 4200	6800 8500 8700
Approximate pressure drop* boiler to turbine, pounds....................................	2.5	9.0
Approximate radiation losses,† saturated steam, 2.5-inch covering, B. t. u. per minute.......	566	396
Approximate radiation loss, 100 degrees superheat, 3-inch covering, B. t. u. per minute...	710	496
Estimated cost of valves, fittings and pipe, all steel, and pipe covering, for one 2000-kilowatt turbine..................................	$2900	$1830
Estimated saving in first cost of these materials.	——	$1070

* Carpenter, Trans. A. S. M. E., 1899.
† Stott, Assoc. Ed. Ill'g Cos., 1902.

FLANGE DIMENSIONS, TABLES II AND III

Bolt Holes to Straddle Centre Lines

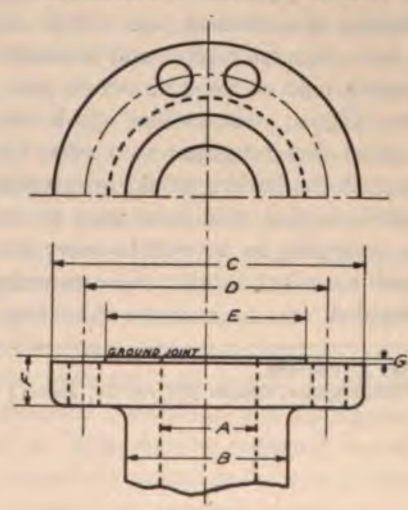

FIG. 3

TABLE II

STEAM-PIPE FLANGES, CAST IRON

A	B	C	D	E	F	G	Holes	Bolt Sizes
2	4	$8\frac{5}{8}$	$6\frac{5}{8}$	$5\frac{1}{4}$	$1\frac{1}{4}$	$\frac{1}{32}$	4–1"	$\frac{7}{8}$
$2\frac{1}{2}$	$4\frac{1}{2}$	$8\frac{7}{8}$	$6\frac{7}{8}$	$5\frac{3}{4}$	$1\frac{1}{4}$	$\frac{1}{32}$	4–1"	$\frac{7}{8}$
3	5	$9\frac{1}{2}$	$7\frac{1}{2}$	$6\frac{3}{8}$	$1\frac{1}{4}$	$\frac{1}{32}$	8–$\frac{7}{8}$"	$\frac{3}{4}$
$3\frac{1}{2}$	$5\frac{1}{2}$	10	8	$6\frac{7}{8}$	$1\frac{1}{4}$	$\frac{1}{32}$	8–$\frac{7}{8}$"	$\frac{3}{4}$
4	6	$10\frac{1}{2}$	$8\frac{1}{2}$	$7\frac{3}{8}$	$1\frac{3}{4}$	$\frac{1}{32}$	8–1"	$\frac{7}{8}$
$4\frac{1}{2}$	$6\frac{1}{2}$	11	9	$7\frac{7}{8}$	$1\frac{3}{4}$	$\frac{1}{32}$	8–1"	$\frac{7}{8}$
5	7	12	$9\frac{3}{4}$	$8\frac{1}{2}$	$1\frac{3}{4}$	$\frac{1}{32}$	8–$1\frac{1}{8}$"	1
6	$8\frac{1}{4}$	$13\frac{1}{4}$	11	$9\frac{3}{4}$	2	$\frac{1}{32}$	8–$1\frac{1}{8}$"	1
7	$9\frac{1}{4}$	$14\frac{1}{4}$	12	$10\frac{3}{4}$	2	$\frac{1}{32}$	12–$1\frac{1}{8}$"	1
8	$10\frac{1}{4}$	$15\frac{5}{8}$	$13\frac{1}{8}$	$11\frac{7}{8}$	$2\frac{1}{4}$	$\frac{1}{32}$	12–$1\frac{1}{8}$"	1
9	$11\frac{1}{4}$	$16\frac{1}{2}$	$14\frac{1}{4}$	$12\frac{7}{8}$	$2\frac{1}{4}$	$\frac{1}{32}$	12–$1\frac{1}{4}$"	$1\frac{1}{8}$
10	$12\frac{1}{2}$	$17\frac{1}{2}$	$15\frac{1}{4}$	14	$2\frac{1}{4}$	$\frac{1}{32}$	16–$1\frac{1}{8}$"	1
12	$14\frac{1}{2}$	20	$17\frac{3}{4}$	$16\frac{3}{8}$	$2\frac{1}{2}$	$\frac{1}{32}$	16–$1\frac{1}{4}$"	$1\frac{1}{8}$
14	$16\frac{1}{2}$	23	$20\frac{1}{4}$	$18\frac{7}{8}$	$2\frac{1}{2}$	$\frac{1}{32}$	20–$1\frac{1}{4}$"	$1\frac{1}{8}$
16	$18\frac{1}{2}$	25	$22\frac{1}{4}$	$20\frac{1}{8}$	$2\frac{1}{2}$	$\frac{1}{32}$	20–$1\frac{3}{8}$"	$1\frac{1}{4}$
18	$20\frac{3}{4}$	$27\frac{1}{2}$	$24\frac{1}{2}$	$22\frac{3}{4}$	$2\frac{3}{4}$	$\frac{1}{32}$	20–$1\frac{3}{8}$"	$1\frac{1}{4}$

TABLE III

STEAM-PIPE FLANGES, STEEL

A	B	C	D	E	F	G	Holes	Bolt Sizes
2	$3\frac{1}{4}$	$8\frac{5}{8}$	$6\frac{5}{8}$	$5\frac{1}{4}$	1	$\frac{1}{32}$	4–1"	$\frac{7}{8}$
$2\frac{1}{2}$	$3\frac{7}{8}$	$8\frac{7}{8}$	$6\frac{7}{8}$	$5\frac{3}{4}$	1	$\frac{1}{32}$	4–1"	$\frac{7}{8}$
3	$4\frac{1}{2}$	$9\frac{1}{2}$	$7\frac{1}{2}$	$6\frac{3}{8}$	$1\frac{1}{8}$	$\frac{1}{32}$	8–$\frac{7}{8}$"	$\frac{3}{4}$
$3\frac{1}{2}$	5	10	8	$6\frac{7}{8}$	$1\frac{1}{8}$	$\frac{1}{32}$	8–$\frac{7}{8}$"	$\frac{3}{4}$
4	$5\frac{1}{2}$	$10\frac{1}{2}$	$8\frac{1}{2}$	$7\frac{3}{8}$	$1\frac{1}{4}$	$\frac{1}{32}$	8–1"	$\frac{7}{8}$
$4\frac{1}{2}$	6	11	9	$7\frac{7}{8}$	$1\frac{1}{4}$	$\frac{1}{32}$	8–1"	$\frac{7}{8}$
5	$6\frac{5}{8}$	12	$9\frac{3}{4}$	$8\frac{1}{2}$	$1\frac{3}{8}$	$\frac{1}{32}$	8–$1\frac{1}{8}$"	1
6	$7\frac{5}{8}$	$13\frac{1}{4}$	11	$9\frac{3}{4}$	$1\frac{3}{8}$	$\frac{1}{32}$	8–$1\frac{1}{8}$"	1
7	$8\frac{3}{4}$	$14\frac{1}{4}$	12	$10\frac{3}{4}$	$1\frac{1}{2}$	$\frac{1}{32}$	12–$1\frac{1}{8}$"	1
8	$9\frac{7}{8}$	$15\frac{5}{8}$	$13\frac{1}{8}$	$11\frac{7}{8}$	$1\frac{1}{2}$	$\frac{1}{32}$	12–$1\frac{1}{8}$"	1
9	$10\frac{7}{8}$	$16\frac{1}{2}$	$14\frac{1}{4}$	$12\frac{7}{8}$	$1\frac{1}{2}$	$\frac{1}{32}$	12–$1\frac{1}{4}$"	$1\frac{1}{8}$
10	12	$17\frac{1}{2}$	$15\frac{1}{4}$	14	$1\frac{5}{8}$	$\frac{1}{32}$	16–$1\frac{1}{8}$"	1
12	14	20	$17\frac{3}{4}$	$16\frac{3}{8}$	$1\frac{5}{8}$	$\frac{1}{32}$	16–$1\frac{1}{4}$"	$1\frac{1}{8}$
14	$16\frac{1}{8}$	23	$20\frac{1}{4}$	$18\frac{7}{8}$	$1\frac{3}{4}$	$\frac{1}{32}$	20–$1\frac{1}{4}$"	$1\frac{1}{8}$
16	$18\frac{1}{4}$	25	$22\frac{1}{4}$	$20\frac{1}{2}$	$1\frac{3}{4}$	$\frac{1}{32}$	20–$1\frac{3}{8}$"	$1\frac{1}{4}$
18	$20\frac{1}{4}$	$27\frac{1}{2}$	$24\frac{1}{2}$	$22\frac{3}{4}$	$1\frac{3}{4}$	$\frac{1}{32}$	20–$1\frac{3}{8}$"	$1\frac{1}{4}$

For steam superheated 100 degrees Fahrenheit above 175 pounds gauge pressure the volume will be increased about 15 per cent, but this amount of superheat will reduce the steam consumption of the turbine about 10 per cent, so that the velocity would be only about five per cent greater than for saturated steam carry-

ing the same load, and the piping system would be equally suitable for either as regards velocity and pressure drop. The pressure drop for the high-velocity piping can only be regarded as approximate. It is based on a steam flow corresponding to 25 per cent overload on the turbine and represents some loss of energy, but probably not a *total* loss of the energy corresponding to the pressure. It seems likely that most of the energy represented by drop in pressure will be converted and become available in the form of a slight amount of superheating or evaporation of entrained moisture. This conclusion seems reasonable, since whatever loss there may be must take the form of heat, and, furthermore, it requires a fixed amount of work to transport the given weight of steam the required distance, regardless of the velocity. If, however, the drop in pressure is all charged up against the high-velocity piping as a loss of energy in the turbine at the rate of .05 pound increase in water rate at full load per pound drop in pressure—a very liberal allowance—it will still be found that the net operating cost will be less than that of the low-velocity piping, if credit is given the smaller piping for its lower radiation losses, which occur 24 hours a day; and if credit is given the smaller piping for the saving in interest, depreciation, and repairs it effects on the capital cost, taking these fixed charges at 10 per cent and the load factor at 33 per cent. Coal is taken at $2.50 a ton, and the evaporation at nine pounds per pound of coal. This, as stated above, is an extreme case, and a higher load factor, higher price for coal, or a few unavoidable elbows in the pipe line, will materially increase the size of pipe and fittings.

Steam Consumption

Although somewhat outside the scope of this paper, the following table of tests* is presented as being of interest in showing the improvements constantly being effected in this turbine by extensive experiment and development:

* Made by A. R. Dodge, Schenectady, N. Y.

TESTS ON 2000-KILOWATT TURBINE

Date 1905	Reference Letter	Kw Load	R.P.M.	Flow Lb. per Hr.	Initial Press. By Gauge	Abs. Back Press. In. Merc.	Vac. Referred to 30" Bar.	Super-Heat Deg. F.	Lb. Steam per Kw-Hour
4-27	A	1970	918	29800	162	1.85	28.15	210	15.12
5-3	B	1040	928	16500	167	1.62	28.38	190	15.87
5-3	C	560	930	10000	163.5	1.60	28.40	210	17.86
5-3	D	2005	918	31700	169	1.63	28.37	125	15.80
5-3	E	1066	928	17400	171	1.52	28.48	105	16.33
5-2	F	1970	918	31900	165	1.79	28.21	105	16.20
5-3	G	0*	932	1530	165.5	1.95	28.05	157	......*

* No load, with field.

The tests that are plotted in Figure 4 were made on a 2000-kilowatt, four-stage turbine of essentially the same design as machines built two years ago, but run at a higher bucket speed and embodying improvements in buckets, nozzles, and so forth, which when incorporated in machines designed hereafter will give the same or better results.

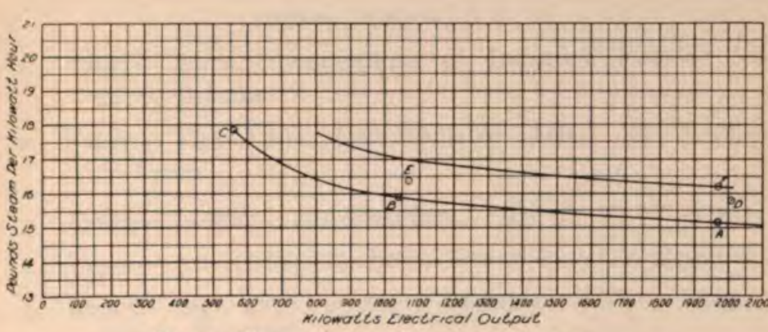

FIG. 4—TESTS ON 2000-KILOWATT TURBINE

It can be shown that the saving in capital cost alone between turbine and engine-driven units effects a saving in fixed charges equivalent to a large reduction of the water rate. The saving of the condensed steam by the turbine where feed water must be bought at ordinary city rates, is also considerable, as is that

effected by the less attendance necessary for the turbine. All of these considerations, however, are of minor importance as compared with the reduction in steam consumption indicated by these tests, because there is hardly any part of the equipment of a power station whose capital and operating costs can not also be reduced as a direct result, such as boilers, stack, coal-handling apparatus, condensers, pumps, and so forth; or, in other words, a reduction of 10 per cent in the water rate of the turbine means a station of 10 per cent greater capacity and output for the same investment, fixed charges, and operating expense.

THE PRESIDENT: The discussion on the report of the committee and on the paper just read will be postponed until to-morrow morning at ten o'clock promptly.

(The meeting adjourned until ten o'clock Wednesday morning.)

ORDER OF BUSINESS

WEDNESDAY, June 7, 1905.

THIRD SESSION, 10 A. M.

1. Paper—"Series Alternating-Current Motors for Industrial Work." By CLARENCE RENSHAW
2. Paper—"A New Type of Single-Phase Alternating-Current Motor for Elevator Work." By G. PERCY COLE
3. Paper—"Long-Distance High-Tension Transmission in California." By JOHN A. BRITTON
4. Report—Present Methods of Protection from Lightning and Other Static Disturbances. ALEX DOW and ROBERT STUART STEWART, Reporters
5. Paper—"The Nernst Lamp—Its Present Performance and Commercial Status." By E. R. ROBERTS

FOURTH SESSION, 8 P. M.

1. Paper—"Some Investigations of Inductive Losses." By E. P. DILLON
2. Paper—"The Choice of an Insulated Cable." By WALLACE S. CLARK
3. Paper—"Mercury Arc Rectifiers." By P. D. WAGONER
4. Report—Advertising Methods. PERCY INGALLS, Reporter
5. Report—Sign and Decorative Lighting. LARUE VREDENBURGH, Reporter
6. Paper—"Free Signs and Flat Rates." By C. W. LEE

THIRD SESSION

President Davis called the meeting to order at ten o'clock, and announced the first business to be the presentation of the paper on *Series Alternating-Current Motors for Industrial Work,* by Mr. Clarence Renshaw, of Pittsburg.

Mr. Renshaw read the paper, as follows:

SERIES ALTERNATING-CURRENT MOTORS FOR INDUSTRIAL WORK

The commercial production of the series alternating-current motor, which marks such an advanced step in the development of suburban and interurban railways, is also an important event from the standpoint of central-station managers. The importance of obtaining day loads so that plants may be kept running on a profitable basis at all times instead of for merely a few hours per day, is well recognized, as is also the fact that the ideal system for central-station work is one that permits the operation of all classes of lighting and power service from the same machines and circuits. Except for supplying the most densely populated sections of the larger cities, the polyphase alternating-current system is now the recognized standard for lighting, and by the use of induction motors, power for a majority of purposes may also be supplied. There are certain classes of work, however, for which induction motors are not entirely suitable, and the lack of a satisfactory alternating-current motor suitable for the work to which direct-current series motors are ordinarily applied, has hindered to some extent the use of alternating current in industrial establishments.

The use of alternating-current motors for the operation of mills, factories, etc., offers an excellent chance to central stations to dispose of their surplus daylight power, so that the development of the series motor, extending the classes of work that can be done by alternating current, and thus bringing the system one step nearer to the ideal, is of vital interest and importance.

Polyphase and single-phase induction motors have many excellent characteristics and are well adapted for purposes requiring a constant-speed motor, but it cannot be denied that for the operation of cranes, hoists, and similar machinery used for intermittent service, they are not as satisfactory as series motors.

In most industrial establishments work of this character forms but a small part of the total service for which electric motors are required, although it is sometimes of sufficient importance to necessitate the choice of direct-current apparatus instead of alternating.

In order to permit such establishments to be operated entirely by means of alternating current, special types of induction motors have been designed which can in general perform these classes of service better than the ordinary constant-speed induction motors, although not as satisfactory as the direct-current series motor.

The polyphase induction motor is similar in its characteristics to the direct-current shunt motor, and when this fact is recognized the reasons for the above statement will be evident. Variable-speed machinery, such as is ordinarily operated by direct-current series motors, usually requires a large starting torque, and it is also desired, in general, that the speed of such machinery should vary inversely as the load. The characteristics of the direct-current series motor are such that the torque increases much more rapidly than the current, so that with double full-load current, from two and one-half to three times full-load torque would ordinarily be developed, and also that the speed varies widely with the load. In the case of the direct-current shunt motor, however, or the induction motor, the speed is nearly constant regardless of the load, and the torque is nearly proportional to the current, so that in order to obtain three times full-load torque practically three times full-load current would be required.

The series alternating-current motor, however, has in general the same characteristics as the direct-current series motor, and a line of small motors of this type for both 25 and 60-cycle circuits has now been developed and placed on the market for industrial service.

This type of motor is designated as "SC," the letters indicating "Single-Phase Commutator." By its use cranes, hoists and similar machinery can now be operated as satisfactorily with alternating current as with direct current. The type SC motor is of the same general construction as the single-phase alternating-current railway motor and operates on the same principle. It has long been known that an ordinary direct-current series motor would operate with alternating current, although the operation was not in general commercially satisfactory. The various difficulties, however, have now been successfully overcome.

The performance of these motors is illustrated by the curve sheets, Figures 1, 2, 3 and 4. It should be noted that the characteristic curves of both the 25 and 60-cycle motors are of the

same general shape as those of direct-current series motors. The torque depends entirely on the current, a given current producing a certain torque regardless of whether the motor is running at full speed or any reduced speed. The speed curves are somewhat steeper than those of direct-current motors, the speed falling off more rapidly with heavy loads and increasing more rapidly with

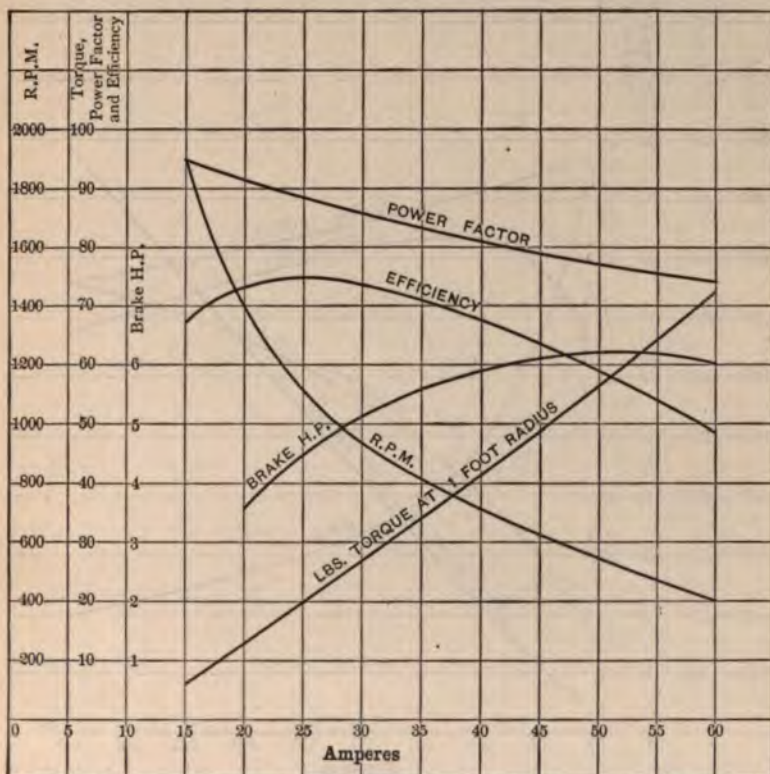

FIG. 1—PERFORMANCE CURVES OF NO. 1, 25-CYCLE, TYPE SC MOTOR

lighter ones. This effect is a function of the frequency of the supply circuit and is consequently much more noticeable in the 60-cycle motors than in those designed for 25 cycles. Even the former, however, will produce a maximum torque of several times full-load torque.

The external appearance of the motors is similar in general to that of direct-current motors, and may be seen in Figures 5,

6 and 7, which show views of No. 2 type SC motor. The principal constructional difference between these motors and direct-current motors, is the magnetic circuit, which is built up of annular punchings having poles projecting inward. These punchings are held together in a cast-iron frame. The frames are made solid

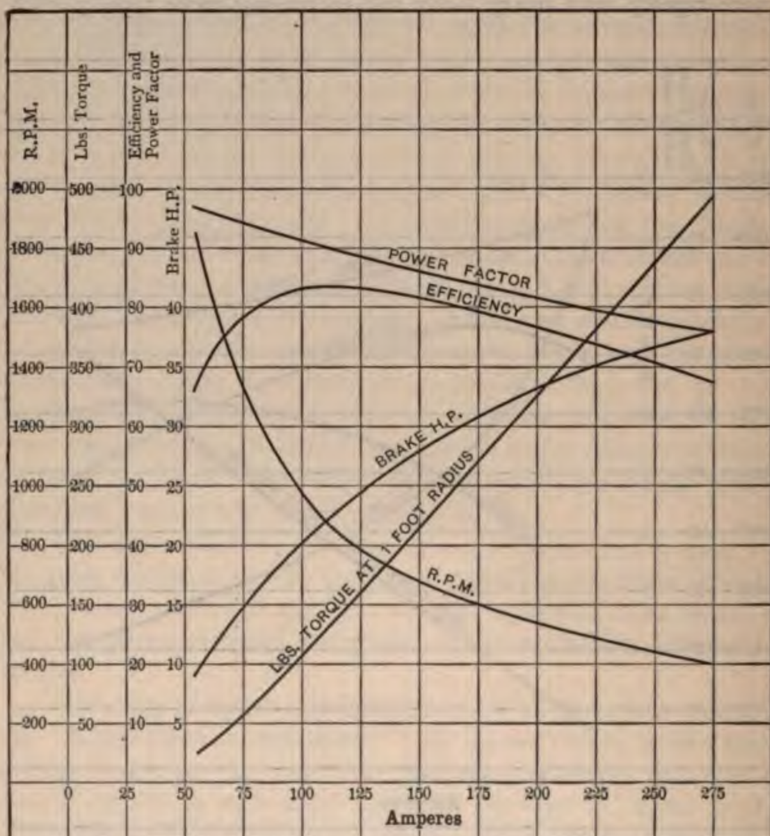

FIG. 2—PERFORMANCE CURVES OF NO. 4, 25-CYCLE, TYPE SC MOTOR

and the armature is put in and taken out endwise. Another difference is the auxiliary field winding (which in reality forms a part of the armature circuit), which is wound in slots in the pole pieces. The object of this winding is to improve the power factor (and hence the maximum torque) by neutralizing the self-induction of the armature.

The 25-cycle motors are wound for a nominal voltage of from 200 to 220, and the 60-cycle motors for a voltage of 110 to 125.

Speed control of the type SC motor, under the direction of the operator, can be obtained by any method that changes the impressed voltage. With alternating current there are several ways

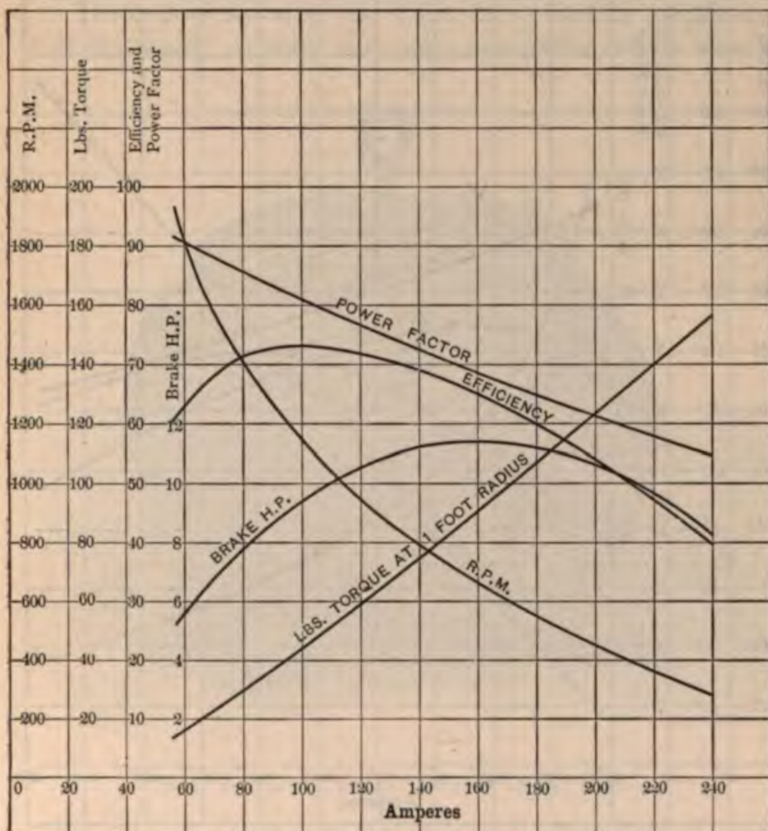

FIG. 3—PERFORMANCE CURVES OF NO. 2, 60-CYCLE, TYPE SC MOTOR

of doing this. The simplest method, however, is by means of a rheostat such as is used in controlling direct-current series motors. On account of its simplicity this method has been adopted as standard, and the controllers and resistances that are used are of the same general type as for direct-current motors of the same current capacity.

The controller used with the No. 1 motor is of the dial or face-plate type, the contacts being mounted radially on a flat vertical surface. A view of this controller may be seen in Figure 8.

For the remaining sizes, controllers of the commutator type are used. In these the contacts are mounted around the edge of

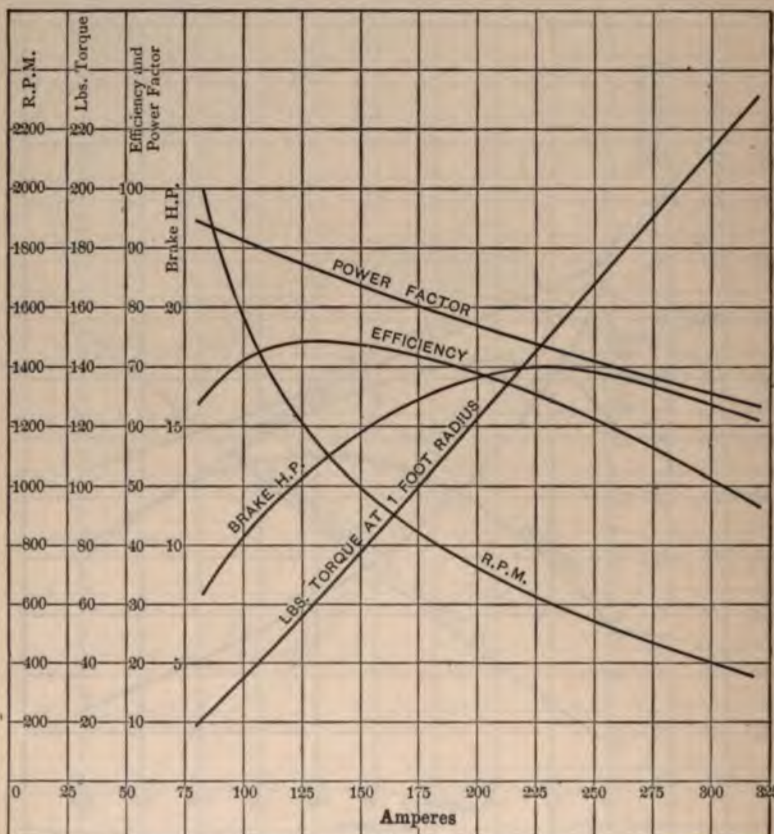

Fig. 4—Performance Curves of No. 3, 60-Cycle, Type SC Motor

a soapstone disc or cylinder. A view of this type of controller may be seen in Figure 9.

Both types of controllers have the necessary resistance mounted within the controller frame. Both types also have four radial rocker arms, each carrying a set of contact fingers. These four arms are moved together by means of a handle or through a

system of bell cranks and levers. The operating rod can be connected to either the right or left-hand side of the rocker arm, so that two controllers may be mounted face to face or back to back as desired. A single movement to right or left applies or reverses the current. The circuit is broken at four different places at the same time, thus diminishing the arc.

The motors operating the hoists of a crane or similar machine are usually provided with automatic brakes, which serve to

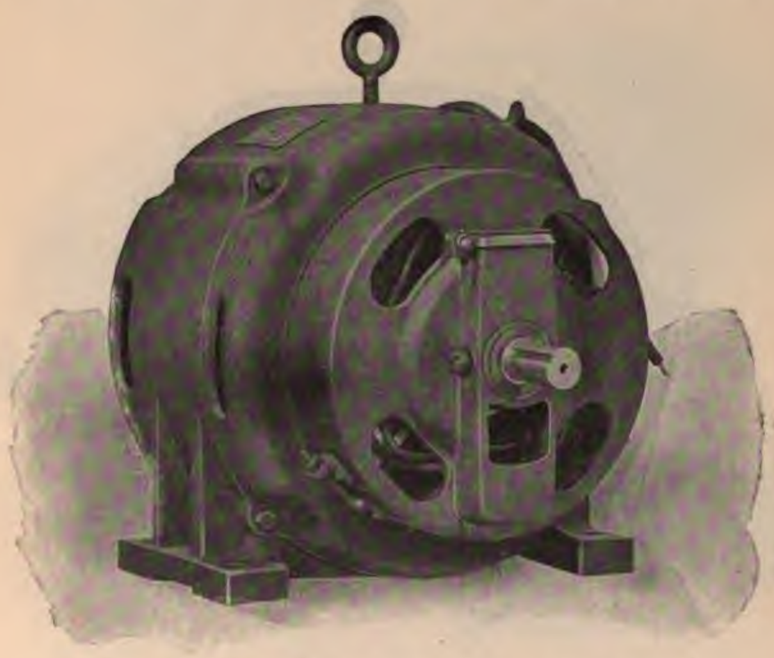

FIG. 5—NO. 2 TYPE SC MOTOR, FRONT VIEW

hold the load in position when current is cut off from the motors. A complete line of such brakes has been designed for use with the type SC motors. These brakes are similar, in general, to those used with direct-current motors or with alternating-current induction motors. They consist in general of a brake wheel, mounted on an extension of the motor shaft at the commutator end, and a set of brake shoes, levers and magnet coils carried on the front end bracket of the motor. When no current is applied

to the motors, the brake shoes are applied to the brake wheel by the action of gravity on a weight attached to the brake shoes and to the armature of the brake magnet by means of a bell crank lever. As soon as the current is applied to the motors the circuit of the brake magnet is closed, the magnet lifts its armature and the weight and thus releases the brake.

The windings of the brake magnet are controlled by means of a small switch mounted on the face of the controller. When

FIG. 6—No. 2 TYPE SC MOTOR, REAR VIEW

the controller is moved to the first notch this switch is closed automatically and current flows through the brake magnet. When the controller is thrown to the open-circuit position the brake-magnet circuit is also opened and the brake is thus locked by the weight. An additional trolley is required across the main frame of the crane for each brake equipment.

Since this type of motor will probably find its greatest field, at least for the present, in the operation of cranes, the special

auxiliary devices, such as controllers, brakes, etc., which have been described above, have been designed for use in connection with the motors for crane service. The same auxiliary devices, however, with possibly slight modifications, are of course applicable to any other purpose.

Where a number of type SC motors are operated from a polyphase system, it will be well to connect some of the motors to one phase and others to other phases, in order that the current drawn

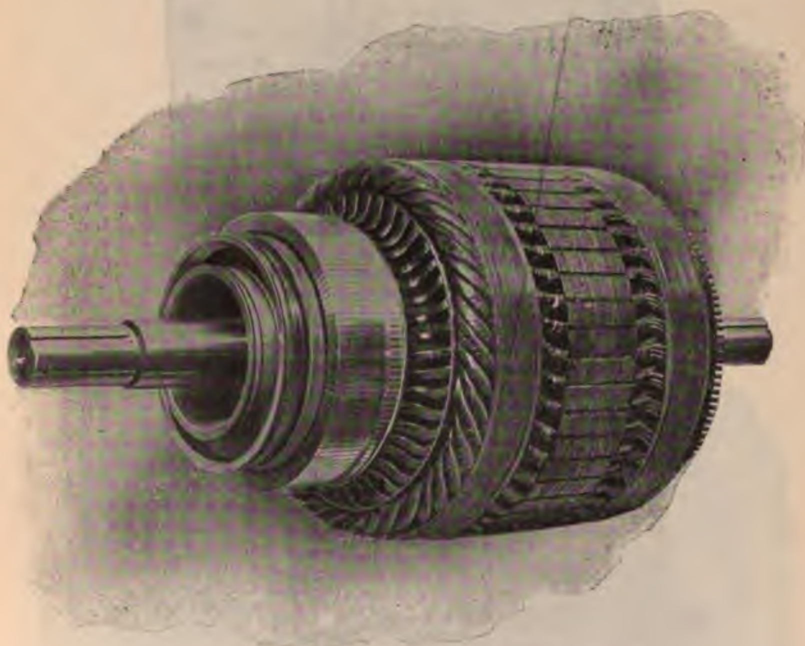

FIG. 7—ARMATURE OF NO. 2 TYPE SC MOTOR

from any one phase shall not be sufficient to unbalance the circuits. An exact balancing is not necessary in such cases, particularly where induction motors are operated from the same system, as in general the induction motors will tend to preserve a balance by taking more current from the lightly loaded phases and less from the heavily loaded ones.

In general, the advantages of the type SC motors for crane service and similar work will be evident at once when it is under-

stood that these motors have the same characteristics as direct-current series motors. The facts, however, may be more readily seen from the following example:

Suppose a 10-ton crane is required, which most of the time,

FIG 8—CONTROLLER AND RESISTANCE FOR NO. 1 TYPE SC MOTOR

however, will be lifting weights of only five tons or less, and suppose the desired speed with the ordinary weight of five tons is

33 feet per minute. The total work required for lifting the weight will then be 330,000 foot-pounds, or 10 horse-power, and since the efficiency of the mechanism will probably not exceed 50 per cent, an output of 20 horse-power at the motor shaft will be required.

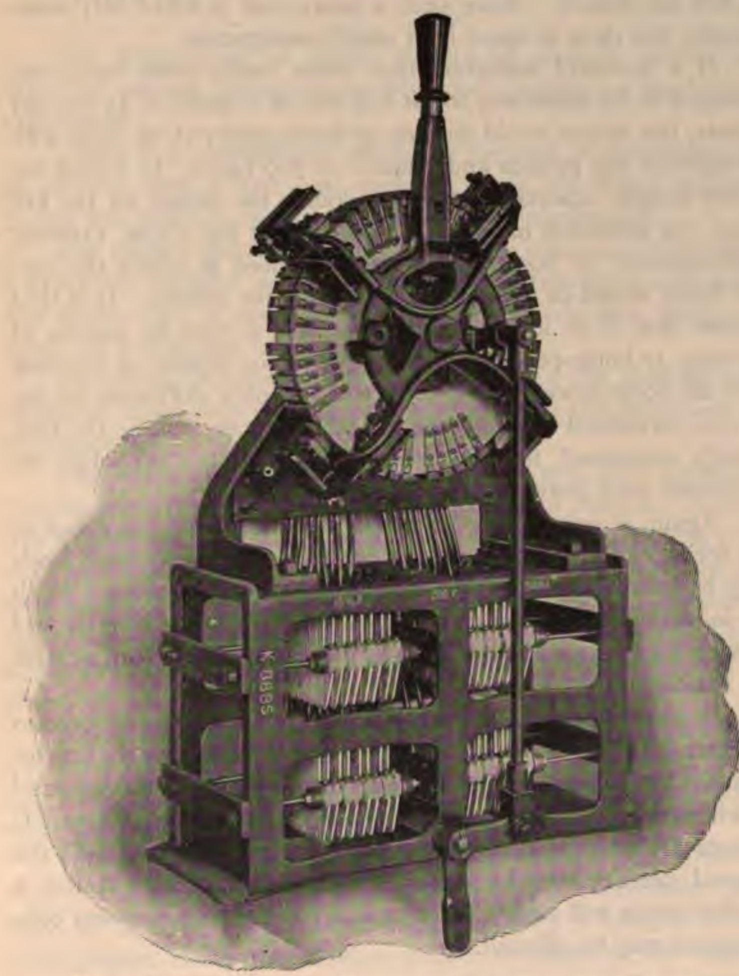

FIG. 9—CONTROLLER AND RESISTANCE FOR TYPE SC MOTORS

The No. 4, 25-cycle, type SC motor, at 20 horse-power, runs at a speed of 980 r.p.m. and develops a torque of 106 pounds at one foot radius on its shaft. If the crane is now called upon to lift

10 tons, which may happen occasionally, a torque of 212 pounds will be required at the motor shaft and, under these circumstances, the motor will run at 680 r.p.m. with an output of approximately 28 horse-power, and the speed of the load will be approximately 23 feet per minute. Since such a heavy load is lifted only occasionally, this drop in speed is of small consequence.

If a standard induction type crane motor were used, and arranged in the same way to lift five tons at a speed of 33 feet per minute, this motor would develop 20 horse-power at its shaft with a torque of 160 pounds and a speed of 700 r.p.m. In lifting the 10-ton weight, however (requiring double the torque for the five tons), the induction motor would still run at 640 r.p.m., exerting approximately 37 horse-power, and the speed at which the load was lifted would be approximately 30 feet per minute. It is thus evident that if an induction motor is used it must be capable of exerting 37 horse-power, while a series motor capable of exerting only 28 horse-power will suffice, and the only difference in the service performed by the crane in the latter case will be the fact, already mentioned, that the speed of lifting drops off when the occasional very heavy loads are applied.

Again, if only a very small load is to be lifted the speed of the series motor rapidly increases, so that, if desired, small loads may be handled very quickly when circumstances permit. With the induction motor, however, the speed of lifting the weights and moving the crane will be practically the same with no load as with the maximum.

In general, cranes and similar classes of machinery have to be installed capable of handling maximum loads much heavier than the loads that they are handling the majority of the time, and it will be readily seen from the above example that if type SC motors are used instead of induction motors, not only will the general performance be more flexible and satisfactory, but a smaller motor will suffice, and a considerable saving in power consumption may be effected.

The President: The paper just read and the following paper relate to allied subjects, and we will discuss them together. The next paper is on *A New Type of Single-Phase Alternating-Current Motor for Elevator Work,* by Mr. G. Percy Cole, of St. Louis.

The following paper was read by Mr. Cole:

A NEW TYPE OF SINGLE-PHASE ALTERNATING-CURRENT MOTOR FOR ELEVATOR WORK

The employment of electric motors for elevator service has been very general during the last few years, mainly for the following reasons:

There is a considerable saving in the cost of installation of an electric over a hydraulic elevator, since the latter requires pumps and tanks in addition to the elevator mechanism.

The electric elevator requires very little space compared with a hydraulic machine, since the whole mechanism—motor elevator and drum—can be installed at the top of the elevator shaft. A space six feet square is usually sufficient.

Operating expenses are not so high, since the simplicity of operation of the electric elevator does not require the attendance of an engineer.

The simplicity of electric-power distribution over hydraulic distribution greatly aids the solution of the problem of control. The electric elevator can be operated by rope or push-button control; the employment of an expert operator is therefore not required. In fact, with this latter method, no operator is needed, since push buttons operating an auxiliary controlling system, which in turn operates the regular controller of the motor, can be placed on each floor.

The large amount of space required by the hydraulic elevator often necessitates the mechanism being placed in an exposed position, thus endangering it by freezing. With the electric motor there is no danger of its freezing up.

The operating expense of an electric elevator as compared with other types is considerably smaller, with the exception, perhaps, of a hydraulic elevator supplied from a central-station accumulator; for in the business centres of many of our largest cities a number of hydraulic elevators can be supplied from a central station at a very reasonable figure.

For the above, and also for many other reasons, the electric type of elevator has found great favor.

The majority of electric elevators now in operation in Amer-

ica employ direct-current motors, the usual pressure of supply in the business centres being 220 volts, and in the outlying districts, 500 volts. Polyphase motors, fitted with slip rings and resistances for variable-speed work, are used to a small extent in this country for operating elevators, but their operation can not be considered to be at all satisfactory. This is chiefly due to the very great disturbing effect on the line that is inherent to the polyphase induction motor when thrown on the full line voltage. Being essentially a constant-speed motor, so unsuited is the polyphase induction motor to the heavy requirements of elevator service that it is extremely unlikely that engineers will try to develop it further in this direction. Elevator service demands a fair amount of torque with reasonable starting currents, and the polyphase induction motor, alongside of the continuous-current motor, in these respects makes a very poor showing indeed.

In New York city the proportion of direct-current motors to polyphase induction motors operating elevators is in the ratio of ten to one; the polyphase motors being employed chiefly in those sections of the city where it is at present impossible to obtain a direct-current supply, and the constructors of elevators have had no alternative but to employ polyphase induction motors.

In many of our largest cities we now find the power companies changing over whole sections from direct to alternating-current supply. In fact, in many cities we already find large areas where direct current can not be had at any price. If, therefore, the electric elevator is to retain its hold, it is imperative that we have a first-class and thoroughly reliable alternating-current motor. As either polyphase or single-phase currents are frequently available, the central station could often connect either type of motor. But as elevator service usually calls for motors of relatively small individual capacity, there are many reasons why service can be given to better advantage single-phase than polyphase. This fact has been recognized by central stations and also by manufacturing companies, and for a good many years a most energetic effort has been made to develop a form of single-phase motor construction suitable for this work. Such a motor, to be entirely satisfactory, should possess the starting characteristics of the direct-current series motor, and the running characteristics of the direct-current shunt motor. Designers have struggled in vain with this problem until quite recently. A type of motor is now

available, however, which affords practically all of the desirable characteristics of the direct-current elevator motor, and it is this motor which the writer desires to briefly describe.

This motor is the invention of Mr. Leo Schuler, an electrical engineer of Frankfort, Germany. In construction it is a combination of the repulsion and induction forms of single-phase motors. Mechanically, the motor consists of an ordinary induction motor frame. It has an ordinary induction motor stator core, built up of laminated sheet steel. The stator winding consists of form-wound coils, distributed in slots around the inner periphery of the stator core. The rotor is built up of laminated steel in the same way as the stator, and carries a progressive wave winding similar to the usual direct-current armature; on one side is provided a commutator, and on the other side three collector rings connected into the winding in polyphase relation.

In operation, the first effort of rotation is secured with connections corresponding to the well-known repulsion motor. After the armature has attained about one-quarter speed the polyphase resistance, connected to the armature through the slip rings, is thrown in and gradually short-circuited as the armature runs up to full speed. The brushes bearing on the commutator in the usual elevator equipment are not completely short-circuited, but have a fixed resistance interposed between them; at no time are the brushes removed from the commutator.

As you are all aware, the repulsion type of motor has starting characteristics very similar to those of a direct-current series motor; that is, a very heavy torque is secured at the first instant of starting. This torque decreases rapidly as the speed increases. Correspondingly the current taken by the stator winding from the outside supply circuit also decreases rapidly, and this is also the case with the current through the repulsion brush circuit. On the other hand, in a single-phase induction motor the torque on the rotor at rest is zero, but increases gradually to a maximum as the speed increases toward full speed. By making use of a combination of these torques the inventor of this motor has developed a machine that has exactly the torque characteristics necessary for elevator and hoist service, and has substantially combined in a single machine two heretofore well-known forms of single-phase motors. Torque at any speed, it will be seen, is approximately equal to the sum of the torques due to the repulsion effort on the

commutator end of the motor and to the induction motor effort on the slip ring end of the motor.

Elevator service usually requires from 40 to 50 per cent excess of full-load torque at the first instant of starting,and the most satisfactory types of direct-current elevator motors provide this torque with a first rush of current not to exceed 50 per cent in excess of the full-load running current. In other words, a good motor for electric elevator work should develop the same torque per ampere of starting current as is developed per ampere of running current. The single-phase motor described in this paper is capable of a development of such a starting efficiency; in fact, by a suitable arrangement of starting resistance it is quite possible to secure a starting torque per ampere appreciably in excess of the running torque per ampere. One of the novel features of this motor is that it is capable of speed control for quite a percentage of its speed range by regulation of the polyphase resistance. It has been experimentally found that successful regulation, down to as low as half-speed, can be secured without trouble—the motor acting electrically as would a series direct-current motor under armature resistance control.

This motor may properly be called a repulsion induction motor since it starts as a repulsion motor, and runs practically entirely as a single-phase induction motor.

Figure 1 shows one of these new single-phase elevator motors direct coupled to an elevator mechanism fitted with rope control. The single-phase supply circuit, also the controller, can be clearly seen at the left of the cut.

This outfit has been in practical service over a period of five or six months and has operated with extremely satisfactory results. Electric control mechanism has not as yet been developed by the manufacturers, but these features will be brought out as adaptation of the motor to prevailing forms of standard elevator construction is effected in co-operation with the various prominent elevator manufacturers of the country.

There has been considerable inquiry as to the amount of sparking developed on the commutator of these equipments. The writer may say that the sparking is practically *nil.* The life of the commutator is predicted to be equal to that of best direct-current elevator motors.

Among the more conspicuous advantages of this motor over

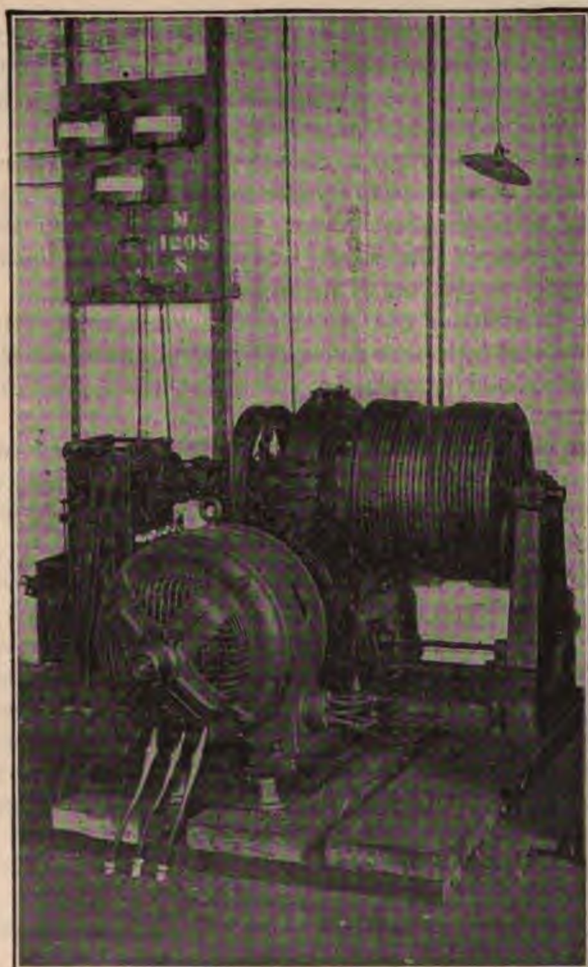

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FIG. 1—SINGLE-PHASE MOTOR FOR ELEVATOR, HOIST AND TRAVELING CRANE SERVICE

The above cut illustrates a very simple combined freight and passenger outfit in service in the city of St. Louis.

other types used for elevator work may be enumerated the following:

(*a*) In this type of motor, it is not the line current, but simply the induced armature current that is being commutated. This allows of the primary stator winding being wound, say, for any convenient pressure up to 1000 volts.

(*b*) Control can be from a distance, since only a throw-over switch is required to reverse the motor.

(*c*) Being a single-phase motor, the simplicity and lessened first cost of the supply circuit distribution bear very largely on the cost of the installation.

(*d*) The commutator can be kept very small, since it is only traversed by a large amount of current during the starting period, and when under full speed, takes practically no current.

(*e*) Since the load is not applied abruptly to the circuit, but gradually, this elevator motor may have its supply circuit attached to the same transformer carrying lights, without affecting the lights.

(*f*) The power factor of the motor is quite high, being about 80 to 85 per cent, both in starting and running speed. It is worthy of note that in polyphase induction motors used for this same service, although a high-power factor is shown at starting, the average running power factor is only 36 per cent, showing that the polyphase motor when used for elevator service was much larger than the average conditions would call for; but it is necessary to provide this capacity in order to accommodate any heavy loads that must occasionally be carried, and to provide sufficient static torque. The high-power factor at starting of the polyphase motor is simply due to the enormous copper loss due to the heavy starting currents.

(*g*) This motor is capable of standing heavy overloads. It will develop from 50 to 60 per cent overload for short intervals without injury to the windings.

(*h*) Low starting current, which is inherent in this type of motor, makes it possible to operate it from one leg of a two or three-phase circuit without unbalancing the circuits.

The connections for operating on different circuits are shown in Figure 2.

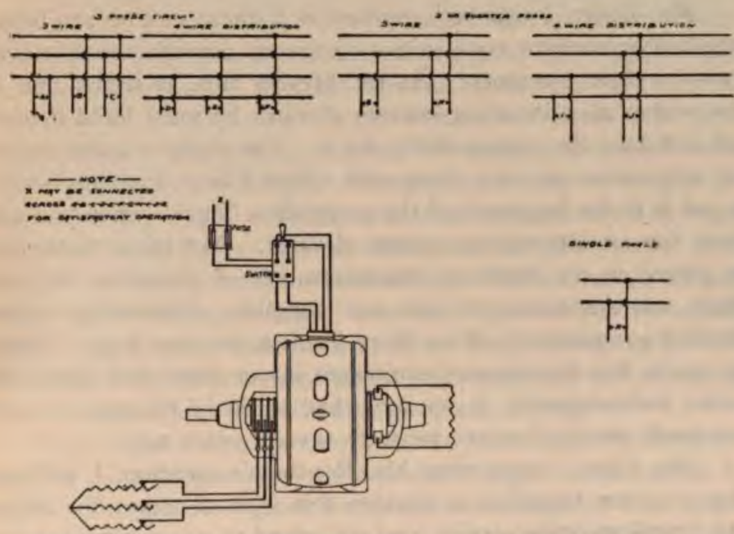


FIG. 2—CONNECTIONS FOR OPERATING ON DIFFERENT CIRCUITS

In conclusion, I may state that we believe we have in this motor one that is in every respect the equal, and in many ways the superior, of the best type of direct-current elevator motor. Its characteristics are such that the acceleration can be made anything desired. The field that it will occupy is indeed very broad. The need of a practical, variable-speed, alternating-current motor has long been felt; and it is our belief that the above described motor will supply that want.

DISCUSSION

MR. RENSHAW: I should like to ask Mr. Cole if it is intended to apply this motor to other purposes than elevator service, such as the operation of machinery of the kind ordinarily used with direct-current series motors. I notice in a circular that apparently describes the same motor that the motor can be adapted for hoists and cranes, and I should like to ask what changes are made in order to adapt the motor for such purpose.

MR. EGLIN: I should like more detailed information upon one statement made by Mr. Cole on page 204, where he says, "In

many of our largest cities we now find the power companies changing over whole sections from direct to alternating supply." I wish he would give us the names of some of the cities.

Mr. Dow: I ask both gentlemen if these motors are being supplied by elevator companies—companies manufacturing elevators—to their elevators? At the present time it seems that if one wishes an alternating-current elevator he must build it himself and take the responsibility for it. The elevator-manufacturing companies—at least those with which I have done business—to put it in the language of the mountains, "duck" when you ask them for an alternating-current elevator. Are these motors to be placed in the hands of manufacturers of elevators, and are these manufacturers to put out complete alternating-current elevator equipments? If so, there seems to be some hope. But if we are to buy the elevator equipment in one place and install the motor independently, as we have had to do in the past, we are not much ahead of where we were several years ago.

Mr. Cole: Answering Mr. Renshaw's question, I will say that it is our intention to develop this type of motor for hoists and traveling-crane service, and we intend to co-operate with the manufacturers of traveling cranes to that effect; and the same with the elevator manufacturers. In one of our bulletins we say: "The installation of the elevator outfit should be made by an elevator manufacturer, and it is our expectation to co-operate with you in having the installation contract taken in the name of reliable elevator companies, to whom this company will supply the motors and speed controllers. It will facilitate the adaptation of this apparatus to installations you may have in hand by your recommending to us such elevator companies as you desire to bid on any given installations, and we will at once place such elevator companies in a position to bid intelligently on the necessary equipment, with installation and erection charges included." This is our intention, and we are already co-operating with several manufacturers of elevators to that effect.

Answering the question in regard to the cities that are changing over whole sections from direct to alternating current, I can not name the exact cities at present, but I know that it is the case in a good many places. In the city of St. Louis, for instance, there is a section in which you can not obtain anything but alternating current, and I believe this is true in many other cities.

I have been informed to that effect, but can not at present give the name of each city where that change has taken place.

Mr. Renshaw: I would call attention to the fact that, in general, the type of motor described by Mr. Cole—in which I have been much interested—seems to me to correspond closely to the direct-current, compound-wound motor, and for such service as cranes and hoists this type of motor is but very little better adapted than a shunt-wound motor. A compound-wound motor, if the compound winding is of such an amount as to give the motor constant speed, is in the same class for such work as cranes and hoists as is a shunt-wound motor, and so has very few of the advantages obtained from a series motor. Of course, in elevator service the compound-wound is what is desired; but for cranes, hoists, and work of that class, an alternating-current motor with series characteristics is essential in order to get the full advantage that is obtained from direct-current crane service.

Mr. Cole: In connection with the motor that Mr. Renshaw describes, on page 195, at the top of the page, he states that the 25-cycle motors are wound for a nominal voltage of from 200 to 220 volts and the 60-cycle motors for a voltage of 110 to 125 volts. I ask why can not the 60-cycle motors be wound for the same voltage as the 25-cycle motors, or to any convenient voltage up to 500 or 600?

Mr. Renshaw: The voltage depends largely on the size of the machine. A certain number of commutator bars are required, and the higher the frequency, the greater the number of commutator bars for any given voltage. For small machines, the large number of commutator bars required for a high voltage would make the bars too narrow for mechanical strength and would make an impossible construction, and it is on that account that the voltage is limited.

DISCUSSION ON STEAM TURBINE

The President: We will now take up the discussion of the steam turbine, the reports on which were presented yesterday. Do any of the members wish to ask questions relative to the matter?

Mr. McCabe: I ask Mr. Kruesi the names of any companies that are operating turbines with exhaust steam, as he spoke of yesterday.

Mr. Kruesi: There are no such turbines out as yet. Some are nearly completed, and quite a number are ordered, but none are out.

Mr. Eglin: I would only care to add one point to the report presented by the committee. We believe that we shall have considerably more data on tests, and shall possibly have some information on this question of using turbines on exhaust steam—referred to in the report—before the report is printed in the proceedings. We knew of one or two proposed cases, but the turbines were not installed and that is the reason why they were not entered in the report. There are two sets ordered for the Philadelphia Rapid Transit Company, and we expect to get information concerning those machines.

The committee also has some information that may or may not be useful—information of a general character—and any member who may desire such information can get it by correspondence.

The President: If there is no further discussion we will pass on to the next paper, *Long-Distance High-Tension Transmission in California,* by Mr. John A. Britton, of San Francisco. Is Mr. Britton in the room? As Mr. Britton's paper has been printed and he does not seem to be here to present it, the paper will be read by title and published in the proceedings.

LONG-DISTANCE HIGH-TENSION TRANSMISSION IN CALIFORNIA

The state of California is entitled to the credit for initial, original and pioneer work in long-distance electrical transmission, not only in the actual operative length of lines, but also in the high pressures used in such transmission. The progress made by the financiers and engineers in this state, during the past ten years, has been so phenomenal as to attract world-wide attention, with the result that there is a constant stream of those interested, from all parts of the world, to the Coast, to observe the original work being done. Not only is California concerned in its trials and triumphs in long-distance transmission, but it has been the pioneer in high-head hydraulic work, as developed for large units. A recitation of the developments of electric transmission in the state would occupy more time than your patience would admit of, but a brief résumé of what has been accomplished in the past ten years, all now under the control of the California Gas and Electric Corporation, may not prove an uninteresting one.

In the year 1888, attention in the engineering world was attracted by the Folsom Water Power Company determining to build a dam across the American River, near the town of Folsom, and to erect a power house some two and one-half miles south of the dam on the river, conveying water by a canal having a capacity of 40,000 miners' inches, to low-head turbine wheels, under a head of 65 feet. Four 750-kilowatt units were installed, generating current at 800 volts, stepping up to 10,000 volts, and conveying the current thus generated to the city of Sacramento, 22 miles distant. The promoters of this enterprise were discouraged by the inability at that time of engineers to guarantee that 10,000 volts could be safely carried that distance for commercial purposes. In 1895, this dream became a reality, and Sacramento city was supplied with current generated at Folsom. While the insulation provided gave more or less trouble initially, this was gradually overcome. In 1892, the late A. W. Decker, electrical engineer, acting for the San Antonio Light and Power Company, at Pomona, Cal., recommended the installation of electric equipment at the power plant of that company, to convey by means of

step-up transformers a pressure of 10,000 volts over approximately 16 miles of line, to the city of Pomona. The generators as finally installed delivered single-phase current at a pressure of 500 volts, and the transformers were wound in the ratio of one to two. There were ten transformers in service on the primary,

Fig. 1—Power-Houses and Transmission Lines of the California Gas and Electric Corporation

giving 10,000 volts with a capacity of 6 kilowatts each installed. Glass insulators were used upon this line.

In 1895, there was begun the construction of a water-power plant near Nevada City, in Nevada County, in the state of California, to transmit about 1000 horse-power a distance of five miles,

with generators wound direct for 5000 volts. The water was conveyed from a dam on the South Yuba River through three and one-half miles of flume, having a capacity of 8500 cubic feet per minute, and delivered to a 42-inch pipe, 286 feet long, with a head of 190 feet. There were installed at that time two 330-kw units.

From these small beginnings has grown a system throughout the state, aggregating in generator capacity at present installed, over 50,000 kilowatts, and units of 5000 kilowatts with varying heads up to 1530 feet. In the central part of the state, utilizing the waters of the western slope of the Sierra Nevada mountains, there are at the present time, in continuous operation, 577 miles of ditches, 25.5 miles of flumes, operating 14 water-power plants, having installed 41 generators, with a rated capacity of 50,790 kilowatts, and having a water storage in numerous lakes aggregating over 3000 million cubic feet, or 1,500,000 miners' inches for 24 hours. From these power-houses there are in continuous service 715 miles of pole line and 734 miles of circuit operated at 50,000 to 60,000 volts, and 479 miles of circuit at voltages varying from 10,000 to 50,000, and 90 miles at lesser voltages, not including any local distribution. Power is delivered to 94 substations, with 75,000 kilowatts in transformer capacity installed, scattered over 21 counties and 33 cities in the state, representing a population of over 60 per cent of the entire state of California, and covering an area of 15,000 square miles. This power is regularly transmitted 232 miles, and by reason of certain conditions at times existing at the different power plants necessitating the transmission over all lines from one power plant, has been successfully operated 325 miles at 55,000 volts.

In addition to the transmission of power, as heretofore and hereafter enumerated, it may be interesting to know that the high-pressure wires supply 1961 miles of distribution wires in service, from 2300 to 5000 volts, and serve approximately 20,000 consumers for lighting, and motors of 100 horse-power and less, totaling 40,000 horse-power.

As the writer has been requested to confine his statements particularly to the subject of high-tension work, and, in a general way, avoid all technical descriptions, avoidance will be made of unnecessary details of power-house operation, or of the operation of the hydraulic systems in connection therewith, and only so far as it may be necessary to illustrate a point made, this paper will be concerned solely with the transmission lines.

In no other portion of the globe where long-distance transmission under extreme high potential has been used, do climatic conditions exist similar to those in California, and this must be particularly borne in mind when considering the work that has been done, the problems solved, and the successful conclusions arrived at in the determination that there is no limit, except that of the earning capacity on capital, to the carrying of current over wires to any distance.

As above stated, power is obtained from the waters flowing from the west slope of the Sierra Nevada mountains. These mountains are snow-capped the year round, and some of the power-houses are within the snow belt which exists during the winter season. Following down the mountain sides, these pole lines emerge into the vast Sacramento and San Joaquin valleys, which extend from Sierra County on the north to Kern County on the south, a distance of approximately 350 miles, and will average about 60 miles in width. After leaving the valleys, the pole lines cross the Coast Range, lying between the valleys and the Pacific Ocean, and generally follow the contour of the bays of San Francisco, San Pablo and Suisun, until they reach the commercial centres of distribution. In this long distance traversed, they are subjected to extreme climatic conditions—from the colds and frosts of the mountains to the severe heat of the valleys, and to the cooling fog-laden winds from the ocean.

The first transmission line to reach the bay shore was that of the Bay Counties Power Company, carrying current generated at Colgate on the Yuba River, about 28 miles northeast of the city of Marysville. This line was started at 44,000 volts, which voltage has since been raised to 55,000. The construction of the line was of round cedar poles, from the state of Oregon, an average height of 50 feet, and the character of construction substantially that now in use, but with a less separation in some instances than was subsequently found necessary. The very many alterations of plans from time to time, as different conditions obtained, to insure service, need not be here recapitulated, the details being confined to present method of construction, as will be illustrated by photographs and cuts annexed. The greatest difficulty encountered in the carrying of the high potential was in and about the bays mentioned, due to the heavy salt fogs that for certain periods of the year hang densely over the land, sometimes lasting for days. In

these particular districts, the insulation has broken down at most unexpected places, causing the burning off of poles, and shortening the line. The new four-part insulator herewith illustrated, with iron pins, has entirely overcome this defect, and for the past season, under the most trying circumstances, no trouble has occurred, the number of hours of shut-downs upon all of these lines being of a negligible quantity.

In addition to the conditions named of transmission over and through countries of varying temperatures, it must be remembered that for seven months of the year, extending usually from April until the first of November, no rain falls within the district named, and where the pole lines run along or adjacent to the public highways, where heavy teaming for all purposes is carried on, they are covered with a fine dust, which arises from traffic, and are subjected at times to extremely hot north winds. For the remaining five months of the year the lines are subjected from time to time to heavy rains and to the high winds accompanying the winter storms. Bearing all these facts in mind, it is nothing short of remarkable that within a period of not over four years such wonderful results have been obtained in transmitting current over the distances involved; for the establishment of the Colgate plant, and the carrying of current into the city of Oakland, its initial distributing point, occurred in the year of 1901.

One of the greatest engineering feats ever accomplished, and one that has never received from the engineering world the attention which it deserves, was the construction, in 1901, of the famous Carquinez span of four steel cables, suspended from steel towers (see Figure 2). This span crosses the Carquinez Straits, connecting San Pablo and Suisun bays, and is 4427 feet in length between towers, having at its maximum point of dip an elevation of 206 feet above high-water line. The maximum sag of the wire between the two steel towers on the north and south sides of the straits is 257 feet. The main tower, in Solano County, on the north side of the straits, is 224 feet in height, and the bluff at the point of construction is 162 feet above tide water; on the south side the tower is 64 feet in height, and the bluff 400 feet above tide water. The accompanying sketch will convey a very accurate description of this span. It is interesting to note that this crossing has given absolutely no trouble in operation. Both of the towers mentioned are used for distributing stations to the different manu-

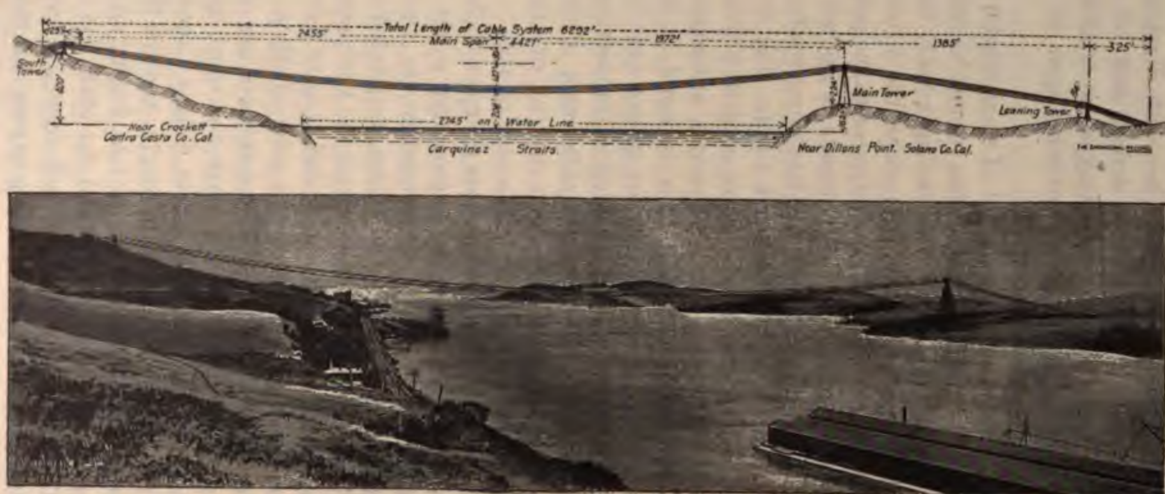
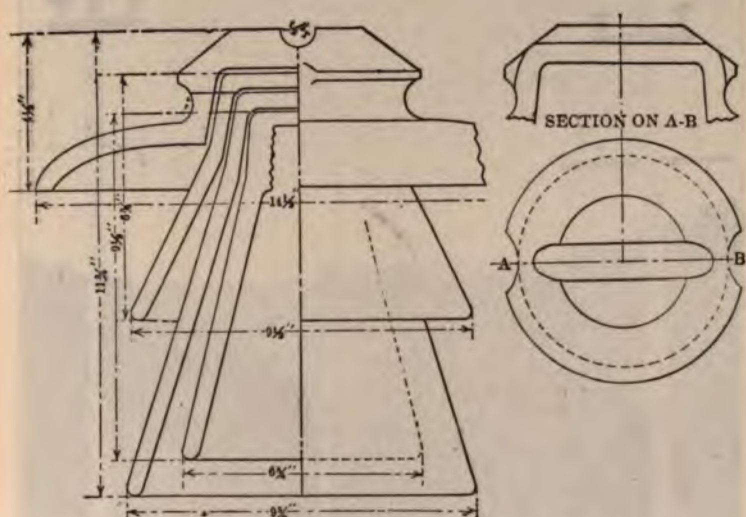


FIG. 2—CROSSING OF CARQUINEZ STRAITS

facturing cities along the bay shore, besides serving as general switching stations.

In the ordinary construction, spans up to 1800 feet in length are constructed in the mountains across deep ravines, using ordinary 40-foot round cedar poles for this purpose. A good sample of this work is shown in the photograph attached, in connection with the spans from the de Sabla plant to the Valley Counties Power Company, in Butte County.

Experience has demonstrated that the form of lightning arrester which gives good service at low voltage is absolutely useless on high-tension lines. While these were first installed, they have



FIGS. 3 AND 4—ILLUSTRATION OF 60 000-VOLT INSULATORS

since in every case been abandoned. At the present time nothing is used but the Horn Gap arrester. As the voltage of the lines has been raised, and the insulation increased, the damage due to lightning is steadily decreasing. It is well to state that beyond the line of the foot-hills of the Sierra Nevada mountains, lightning rarely occurs; possibly once a year throughout the Sacramento and San Joaquin valleys and along the bay shore are there any discharges of lightning that would be detrimental to the lines.

The first construction of lines in this state was 40 to 50 poles to the mile, insulators being used at a maximum cost of 15 cents.

All new lines are now being constructed on the basis of 20 poles to the mile, and the four-part insulators illustrated in Figures 3 and 4 are being used, costing approximately $2.00 each, and weighing about 30 pounds. These are the outcome of months of patient work and experiment by the engineers on the Pacific coast. Figure 5

Fig. 5—Illustrates Old Method of Crossing Ravines. Present Construction in Same Place Spanned by One Pole

exhibits graphically the character of construction of pole lines about six years ago, and the ravine illustrated in that picture is now crossed with a single span. Figure 6 shows the general construction of the pole top for 60,000 volts. Figure 7 shows the transmission line from the Folsom plant, heretofore mentioned.

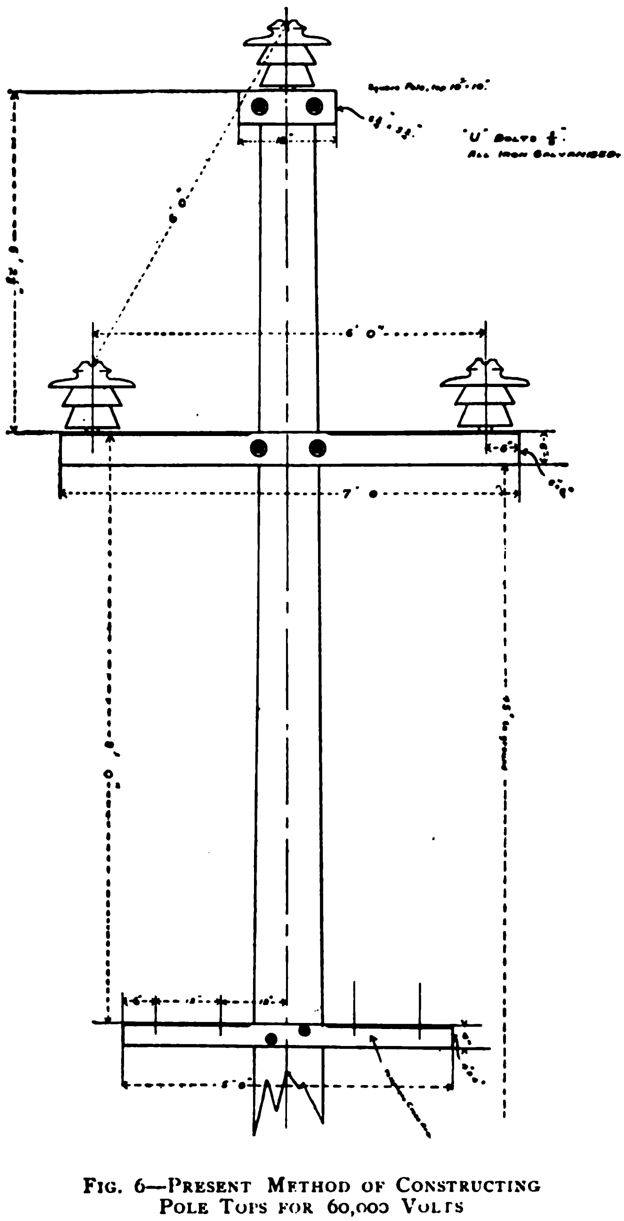


FIG. 6—PRESENT METHOD OF CONSTRUCTING POLE TOPS FOR 60,000 VOLTS

operating to-day as when it started, with four circuits at 10,000 volts at over 18 per cent loss. These circuits are now being changed to operate at 60,000 volts, and the type of construction

FIG. 7—10,000-VOLT LINE FROM FOLSOM POWER-HOUSE (OLD CONSTRUCTION)

FIG. 8—POLE TOP, WITH GUARDS ON CORNER

as shown in Figure 6, and the loss in the 22 miles of transmission at 60,000 volts, with only one circuit, will be about 2 per cent. Figure 8 illustrates the method of construction at corners, giving

a view of the insulated guards attached to the outward insulators to prevent wires from falling to the ground if pulled over. This

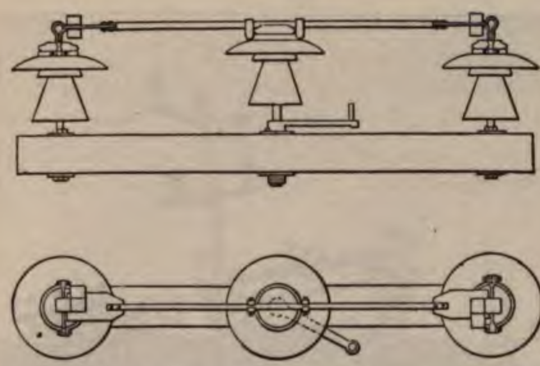


FIG. 9—60,000-VOLT OUTDOOR LINE SWITCH

has proved effective in more than one instance. The construction shown is at the top of a 60-foot round cedar pole. Attention is

FIG. 10—OUTDOOR DISCONNECTING SWITCH

particularly called to the very strong methods adopted in both cross-arm work and braces.

Much work has been done in designing and carrying out the construction of outdoor switches, as shown in Figure 9; and

FIG. 11—OUTDOOR SWITCH

FIG. 12—OLD METHOD OF LINE DISCONNECTION

Figures 10 and 11 will show the switches in place, arranged for three-pole remote-control operation. Figure 12 is a record of the

past, and exhibits some of the earlier attempts at a line disconnecting switch. Experiments have been continuous along the lines of oil switches, and experience has demonstrated sufficiently that this switch as at present constructed is entirely satisfactory and will handle heavy currents under high pressures. Double-break and quadruple-break oil switches are now being made, the

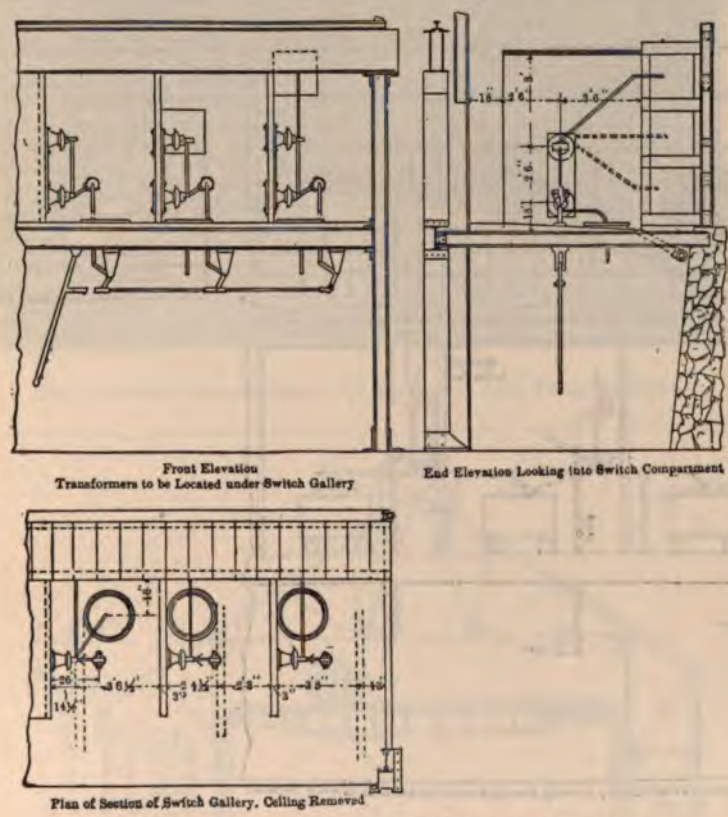


FIG. 13—60,000-VOLT DOUBLE-BREAK OIL SWITCH

latter being used for very heavy service in the large power-houses. Figure 13 shows one form of oil switch, and also shows the method of constructing fireproof switch galleries, the construction of which, so far as the writer is advised, is entirely original with the Pacific coast. The switching is done by opening the three legs at the same time, the single-pole arrangement having been

found to be extremely unsatisfactory for obvious reasons. Figure 14 will illustrate a switch for disconnecting a bank of transformers from the 'bus-bars. Figure 15 will illustrate the past methods of construction of switches and transformers for high-pressure wires, while Figure 16 illustrates the present method, not only of the fireproof switch galleries, but of modern construction of a power-house, showing location of water-wheel, generator, exciter and

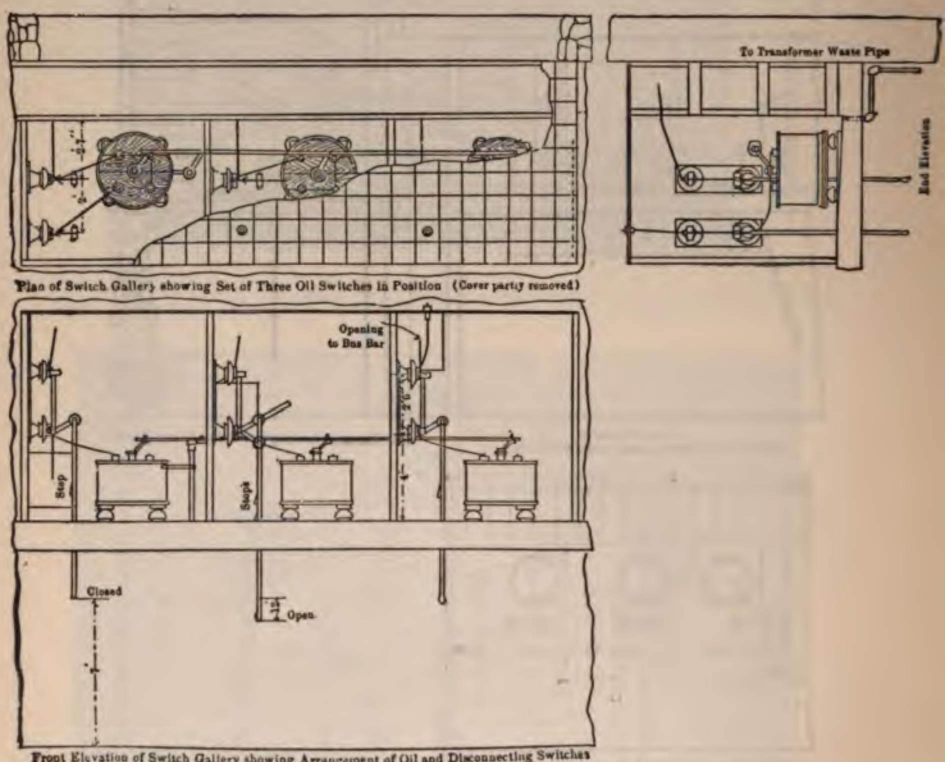


FIG. 14—60,000-VOLT DISCONNECTING SWITCH

switchboard. Figures 17 and 18 illustrate the present method of switching arrangements at substations for connecting and disconnecting lines.

As evidencing the care exercised in protecting low-tension circuits from high-pressure wires where the low-tension parallels the high-tension, in the event that there should be any fall to the

FIG. 15—OLD ARRANGEMENT OF SWITCHES AND TRANSFORMERS

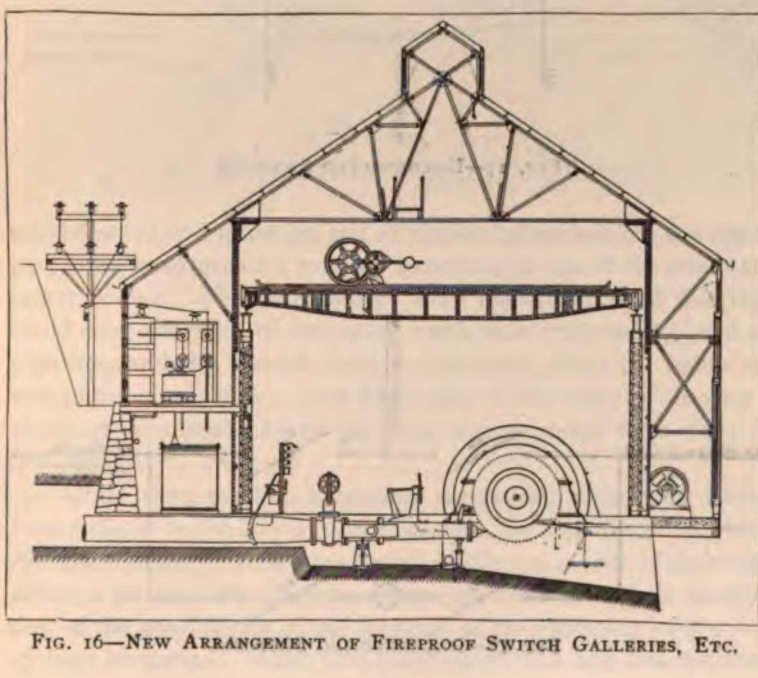


FIG. 16—NEW ARRANGEMENT OF FIREPROOF SWITCH GALLERIES, ETC.

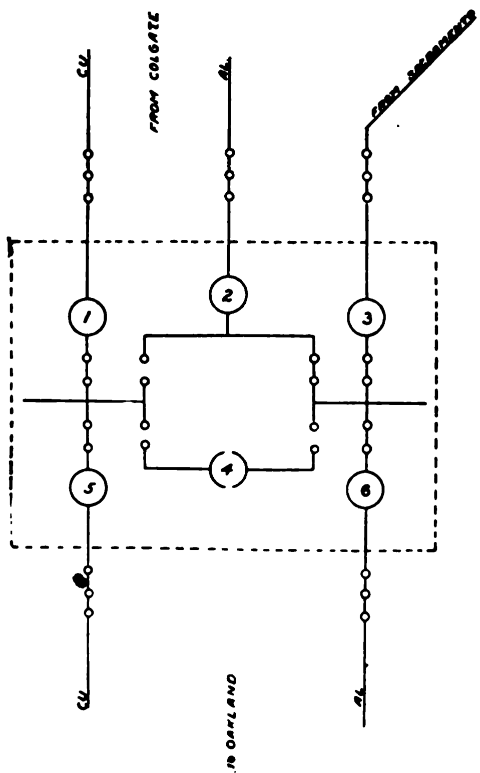


FIG. 17—DISCONNECTED SWITCHES

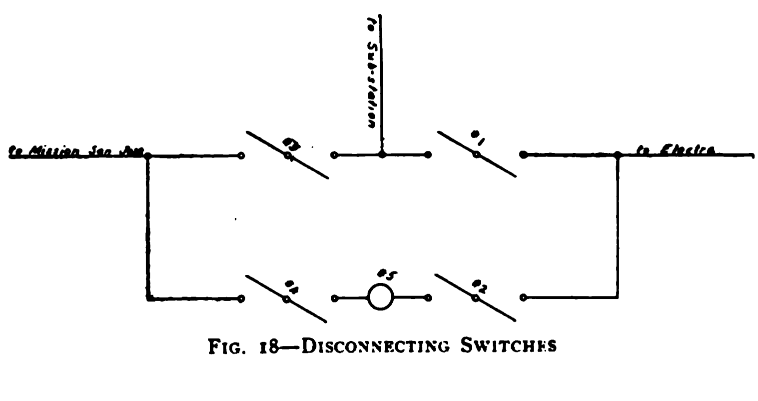


FIG. 18—DISCONNECTING SWITCHES

ground of the insulation of the high tension, Figure 19 is fully illustrative.

Referring to chart Figure 17, this station is midway between Colgate plant, heretofore referred to, and the city of Oakland, on the bay shore. Each line shown represents a three-phase circuit, the large circles representing oil switches. Disconnecting switches are shown on each side of the oil switches. At the station represented in Figure 18 there is no regular operator, and therefore in regular operation switches one and three are closed, and when necessary to open the line, switches Nos. 2, 4 and 5 are closed; then No. 3 or No. 1 opened, and then the oil switch No. 6, which opens the line.

In addition to the illustrations heretofore referred to, the difficulties attendant upon conveying material to the power-houses

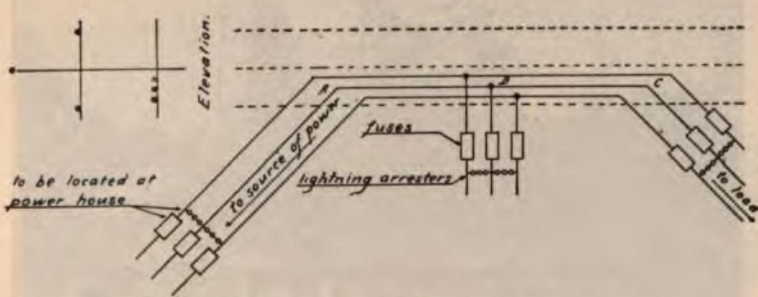


FIG. 19—PROTECTION OF DISTRIBUTING LINES

will be noted in Figure 20, and an illustration of hauling the upper part of an armature of a 5000-kw generator to one of the mountain power-houses. Thirty-six horses were required to pull this machine over six miles of mountain road, from railroad to head of pipe line, and the descent from the penstock down the mountain side to the power-house, over four miles of the roadway, having a grade of approximately 10 per cent, was attended with more or less dangers.

Other than the line heretofore mentioned, conveying power from Colgate to the Bay of San Francisco, the line of the Standard Electric Company to the power plant at Electra, on the Mokelumne River, a distance of 142 miles from San Francisco, is an illustration of the possibilities of the increase of the efficiency of the line by high insulation. When first constructed, this line was operated

at 33,000 volts, which potential was maintained until March, 1904, when steps were taken to operate it in parallel with the other lines controlled by the California Gas and Electric Corporation, the Bay Counties and the Valley Counties companies, and it was at that time increased to 55,000, and has been so operated ever since. The type of insulators in use in March, 1904, has been substituted for the four-part type illustrated, in such sections of the territory of the Standard as by reason of climatic conditions called for a higher insulation.

Outside of the immediate fog belt mentioned, the two and three-part types of insulators have been found extremely efficient for voltages up to 60,000, and experiments have been made to

FIG. 20—HAULING ARMATURE

demonstrate that they will safely carry 80,000 volts without breaking down.

The progress made in the engineering and construction work of power-houses has kept pace with the progress in pole-line work, and insulating and switching devices. The chart herewith, Figure 21, giving the areas of power-houses, graphically shows the contraction of areas in the installation of large units, as it follows closely in the line of distributing stations, where, as can be remembered, the belted units for alternating-current work have increased from 35 kilowatts to the large direct-connected units now in vogue, in some cases as high as 12,000 kilowatts. The first installation made at Electra, in 1899, of five 2000-kw units, called

for a floor space equal to 1.16 square feet per kilowatt; the Colgate installation made in 1897, of 9400 kilowatts, called for 0.98 square foot per kilowatt; the recent installation at the de Sabla power-house of the Valley Counties Power Company, of 9000 kilowatts, called for but 0.4 square foot per kilowatt. The installation now being made at Electra of two 5000-kw units, calls for but 0.288 square foot per kilowatt. The areas given include room for transformers, switches, and so forth.

It will be noted that the first installation at Electra required four times the floor space per kilowatt as compared with the work at present being done, and illustrates more clearly than words can convey the advancement in the past six years. It is believed that the floor area in the new Electra installation is less than that of any other power plant in existence to-day. In these plants there

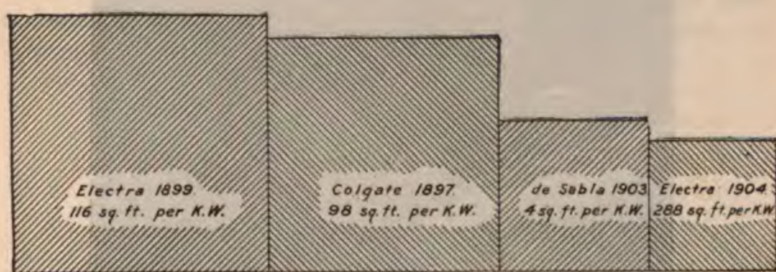


FIG. 21—ILLUSTRATION OF POWER-HOUSE AREAS

is no crowding of apparatus, and there is ample room for all operation or repairs, and in future work it will be safe to assume that this minimum of floor space can be still further reduced. Reduced floor area means, of course, reduced operating expenses, as well as reduced cost of construction.

When it is considered that the operation of these power plants extends to an infinity of uses, from the moving of street cars to the operation of sewing machines, from factories using ponderous machinery and exacting conditions of demand to the most minute uses to which electricity can be applied, and that during the four years of active operation on this coast new contracts are continually being made for the use of electricity against the installation of steam plants that might be operated with the cheapest fuel known (which is California oil at between 55 and 60 cents per

barrel of 42 gallons), it is a tribute to the knowledge, perseverance and energy of the engineers that such work has been accomplished and so perfectly done in so short a space of time. Motors as large as 800 horse-power come on and off the line unnoticed.

From the point in the mountain stream where the diverting dam arrests the onward flow of the water through the ditches con-

FIG. 22—DE SABLA POWER-HOUSE, SHOWING LONG SPANS ON 40-FOOT POLES, CROSSING MOUNTAIN RAVINES

structed upon the sides of the chasms, the flumes across deep canyons, to the utilization of such water at the water-wheel, and then over the lines by which the invisible current is conveyed over the many miles of copper and aluminum wires to points of distribution, there is exercised a watchfulness and care that is

unceasing. Constant lines of patrol are maintained at the reservoirs, on the flumes and ditches, and along the pole lines, and direct telephone connection is made by the patrolmen, over private telephone lines, to the central power-houses. By the construction of the double-pole line from the main power-houses to the bay, constant service is insured, because it is but the work of a moment to switch the high potentials, by means of the switches illustrated, from one line to the other.

Experience with aluminum wire along the bay shores has demonstrated that it is impervious to the action of the atmosphere heavily laden with salt, and quite as effective in that regard as the copper.

THE PRESIDENT: We will now take up the report, *Present Methods of Protection from Lightning and Other Static Disturbances,* by Messrs. Alex Dow and Robert S. Stewart, of Detroit, Mich. Mr. Dow will present the report.

REPORT ON PRESENT METHODS OF PROTECTION FROM LIGHTNING AND OTHER STATIC DISTURBANCES

This report is intended to be a brief of present practice, with notations thereon. It does not present any new theories or devices.

PRELIMINARY —Lightning arresters were built on a kind of "hit-or-miss" plan until Dr. Lodge showed that lightning discharges differed from static discharges in magnitude only, the same laws governing both. When this was recognized the manufacturing companies carried out exhaustive tests with static machines on various protective devices, and in this way developed protective apparatus that could not have been designed had it been requisite to make all tests on live lines during thunder storms.

After long tests with static machines had indicated the best general designs the apparatus was put into actual service in places where thunder storms were unusually severe. Many minor changes have been and are still being made, due largely to the changes in the kind of apparatus to be protected, but the main features of the standard arresters have not been changed in many years.

DUTY OF LIGHTNING ARRESTERS —Transmission lines are occasionally subjected to excessive high-potential strains that would be injurious to generators, transformers or motors, and it is the function of a lightning arrester to protect the apparatus from such strains. These excessive strains are due to the following:

First—Lightning: During a storm, if the potential difference between two clouds or between a cloud and the earth becomes excessive a disruptive discharge occurs. This discharge is usually oscillatory, the frequency of the oscillations being very high. Induced currents are set up in all the surrounding conductors, even when they are several miles distant.

Lines are seldom struck by a direct stroke of lightning, and when struck the damage is not necessarily serious, if the line is struck some distance from the station, for the line chokes back

the discharge. Poles are split by the lightning traveling down them instead of following the line into the station.

A good example of the action of a direct stroke was observed in Detroit some years ago. One of the street-lighting towers was struck in the daytime, when no current was on the lines, the lines being thoroughly grounded at the station a mile away. As the tower was of iron, the main portion of the discharge evidently traveled down this to earth. Two of the switches at the top of the tower were burned out, the current jumping from the tower to the line, the auxiliary cut-out in one of the lamps was raised and the contacts welded together, showing that a very large current had flowed through this contact. This current then traveled down the line wires to the base of the tower and jumped to the case of the switch at the bottom and from thence to earth. Current also traveled down all four guy lines, splintering all the guy stubs. To one of these stubs a guy line to a telephone pole was fastened. A portion of the current jumped to this line and from there to a trolley wire, puncturing the insulator on the hanger. Nowhere else on the line was there any evidence of damage.

The damage sequent to a lightning discharge is in most instances the work of the induced currents set up in surrounding or adjacent conductors. The potential strain is usually from the line to earth, but may be (and frequently is) between the several wires of a circuit. This latter is more likely to be the case on lines in which the wires are strung some distance apart.

Second—High-frequency waves set up by sudden changes of load or by resonance: These waves are similar to the induced currents from lightning, but the frequency is not so high, nor is the potential difference as great. The maximum strain is almost always between the several wires of the circuit.

Third—Static charges: A line insulated from the earth may become charged to a high potential if the climatic conditions are favorable. A very dry atmosphere, hot-wind storms, sand storms and great variation in the altitude of the pole lines are some of the causes of static charges. During severe sand storms the arresters may not be able to keep down the potential of the line, although they may be discharging almost continuously.

THE BEST METHODS OF PROTECTION ARE:

First—Non-inductive high resistances connected from the circuit to the earth.

Second—Lightning arresters. These should have enough resistance in series with them to prevent the discharges from becoming oscillatory.

Third—Overhead ground wires, as described later.

ESSENTIAL FEATURES OF PROTECTIVE APPARATUS:

First—They should discharge at a potential slightly higher than that of the system.

Second—The ordinary working of the system should not be affected by the discharge.

Third—The electric energy of the static disturbance should be dissipated as rapidly as possible.

Fourth—The static waves should be prevented from developing high-potential difference in generators, transformers and other apparatus.

First condition: An ordinary spark gap from the line to earth fulfills this perfectly. The gap can be set to break down at any voltage desired. A spark gap is dispensed with altogether in some arresters, the line being connected to earth through a non-inductive resistance which is high as compared with the resistance of the rest of the circuit. Water jet and tank arresters are examples of this.

Second condition: The gap once broken down, the line current will follow unless some means is adopted for preventing this. Inserting resistance in series with the gap, subdividing the gap into several smaller ones, making the metal cylinders between the gaps of some non-arcing material, increasing the size of these cylinders so as to present a large cooling surface for the arc, and blowing out the arc by a magnet, are the methods adopted at present.

The third condition is very hard to comply with, as static disturbances differ so much from one another. To protect from a direct stroke of lightning, as little resistance as possible should be in circuit. If, however, the line is charged with static electricity, oscillations will be set up in the line when the arrester discharges, unless a certain amount of resistance is in the circuit.

The fourth condition requires the use of choke coils for disturbances due to lightning, or combinations of choke coils and condensers for static waves due to short-circuits and other sudden changes of load.

DESCRIPTION OF THE MAIN PARTS OF STANDARD ARRESTERS

Alternating Current

General Electric Arrester for Two Thousand Volts—Two one-thirty-second-inch air gaps are connected from line to earth in series with a non-inductive high resistance. Cylinders are large, to give a large cooling surface for the arc. The current is kept low by the high resistance used. For protection from stresses between the separate wires of line, half of the gaps are cut out by a bridge connecting the two cylinders which are midway between the line and earth. The arrester thus connected will have the same number of gaps between the lines as from the line to earth. For very high-voltage systems several arresters are connected in series. This arrester should protect very well from ordinary disturbances, but the high resistance does not permit of rapidly dissipating the large amount of energy in a lightning flash.

Westinghouse Arrester for Two Thousand Volts—Six one-thirty-second-inch air gaps are in series from line to earth. Cylinders are made of non-arcing metal. No resistance is used with this when connected to lines fed by 2200-volt generators of moderate size. When a higher potential than 2200 volts is used more gaps are used and a resistance is connected in series with the arrester to prevent an excessive current from the generator flowing through the arrester. This arrester protects from severe flashes very well, but as the length of air gap is longer than in the General Electric arrester, a higher difference of potential is required to break down the gap. On discharging a line that has a static charge oscillating waves may be set up in the circuit, since no resistance is used.

These two arresters show how differently two companies will sometimes reason in designing apparatus for the same service.

Westinghouse Low-Equivalent Arrester—This was designed some five years ago in order to cut down the number of gaps required in the standard arrester when used on very high-voltage circuits. It consists of a small number of gaps which should break down at a little above the line voltage. In series with these is a high resistance, and shunted across this resistance is a second set of gaps equal in number to the first set. In series with the whole

arrester is a small non-inductive resistance, to keep down the main current. Non-arcing metal is used for the cylinders. The operation is as follows: If the potential of the circuit increases, the series gaps break down immediately. As the resistance of these gaps when broken down is small compared with the high resistance in series with them, practically full-potential strain is put on the gaps shunted across this resistance and they will break down. After the static discharge the arc immediately dies out in the shunted gaps if the arrester is properly designed, and the high resistance cuts the current so low in the series gaps that the arc in these is next extinguished. This arrester combines the good qualities of both those already described, for it furnishes a high-resistance path for small static discharges and a low-resistance for violent discharges.

It was the privilege of one of the writers to install the first of these arresters. A considerable amount of lightning trouble had been experienced with a high-voltage generator, several generator coils and a transformer having been burned out in a single year. The generator always ran through heavy thunder storms, but a little lightning anywhere along the line would cause trouble. The trouble was always due to short-circuits, the discharges never going to earth except through the arresters. The arresters were changed by shunting part of the gaps by a high resistance. No trouble had been reported from this plant three years after this change was made.

Horn Arrester—This consists of a single large gap, the sides of which are horn-shaped metal pieces to which iron pieces are fastened. The theory of the arrester is that the discharge across the gap sets up a magnetic field, which is distorted by the iron pole pieces. This field draws up the arc which follows the discharge to a point where the field will be symmetrical around the arc. At this point the gap will be so long that the arc will be extinguished, provided the current through the arrester is kept low by a non-inductive resistance. When used on very high-voltage systems the air gap has to be very large to prevent excessive current across the gap. To remedy this fault a small auxiliary gap and a high resistance are shunted across the main gap. When a discharge occurs across the auxiliary gap the heat of this starts an arc across the main gap. This would seem to be a defect, for by the time the arc had started across the main gap all the damage might have

been done by the static wave. The reports concerning this arrester are too meagre for us to judge of its operation. It is used on several lines in Europe, but has been tried very little in this country.

Water Jet Arrester—Water jet discharge devices have been used on some of the high-voltage transmission lines in Europe, and these are reported to be operating very satisfactorily. Jets of water are thrown from a grounded nozzle against terminal plates that are connected to the several wires of the circuit. These columns of water furnish high non-inductive resistance paths from the line to earth for any static waves. The power lost is said to be about three kilowatts, and the water used less than one gallon per minute. It would seem that the resistance of the water columns must be so high that it could not dissipate the energy of a violent disturbance with sufficient rapidity.

Direct-Current Arresters—In direct-current service the arc formed by a discharge is much harder to extinguish than in alternating-current service. Fortunately, however, direct-current voltages are usually small.

Thomson Magnetic Blow-Out Arrester—In this the single air gap is between two metallic horns. An electro-magnet is placed with its poles opposite the lower extremity of the gap. This magnet is excited either by the discharge current or by the main-line current. The magnetic field set up blows out the arc immediately. The operation of this arrester is very satisfactory.

Westinghouse Direct-Current Arrester—This is built in accordance with the principle that if the voltage across a gap is very low no arc will be maintained in the gap. A large number of minute gaps are connected in series. Carbon particles are used to form the sides of these gaps. It is necessary in this arrester to keep the lines of carbon particles protected from the air, or an arc will be carried across the air above the carbon and will burn up the arrester. The objection to this arrester has sometimes been made that its operation has to be taken on faith. There is no evidence of discharge unless one is observing the arrester at the time of discharge. Tell-tale papers in a small auxiliary gap connected in series with the arrester would be advisable.

Garton Arrester—Two gaps are connected in series with a non-inductive resistance. Shunted across part of this resistance is a small coil. On discharge the current in the coil lifts an iron

armature, and increases the length of one of the gaps so much that the arc is immediately extinguished. The most serious objection to this arrester is that it contains moving parts. If a second static wave follows immediately after a first, the air gap at this time will be so long that no discharge can occur, and the apparatus on the line may be subjected to a dangerous potential.

Westinghouse Tank Arrester—This was designed many years ago for the protection of large railway stations. Instead of air gaps, a tank of running water is connected directly from the line to ground. The current taken will be small in comparison with the load. The arrester is disconnected from the circuit, except during thunder storms.

CHOKE COILS —With all arresters choke coils are placed between the arrester and the apparatus to be protected.

A coil of wire offers opposition to the passage of an electric discharge through it. The more sudden the discharge the greater will be the opposition. The opposing e.m.f. in the choke coil may be so high that the path across the air gap of an arrester will be easier than through the coil. In the case of lightning the discharges are either very sudden or they are oscillatory discharges of very high frequency, and a coil which offers practically no opposition to the main current is sufficient. The potential at a choke is greater than it would be if the coil were not present, for the potential is the resultant of the advancing wave and of the wave that is reflected by the coil. This resultant will always be greater than that of the advancing wave alone. It is standard practice to divide a choke coil into several parts and to place arresters between these so as to furnish paths to earth for any discharge that has passed the first arrester.

DISTRIBUTION OF ARRESTERS —In long-distance transmission the lines need no protection, and the arresters are grouped at the two ends of the line. Several choke coils are used, and the arresters are connected to the line at several places between the coils, so as to be sure that some of the arresters will be at a maximum point of a static wave.

In distribution networks arresters should be scattered all over the network. There is no general rule as to the number necessary, except that the more arresters installed the better the protection.

In low-voltage networks that are tied together in many places,

if one branch extends some distance from the network, weak spots near the end of the branch are punctured by discharges during thunder storms. Experiments with static machines and small networks of conductors showed the same phenomenon many years ago. A static wave traveling down the conductor is reflected back at the end of the conductor. The resultant of the advancing and reflected waves gives at the end of the line a potential strain that is double that of the advancing wave.

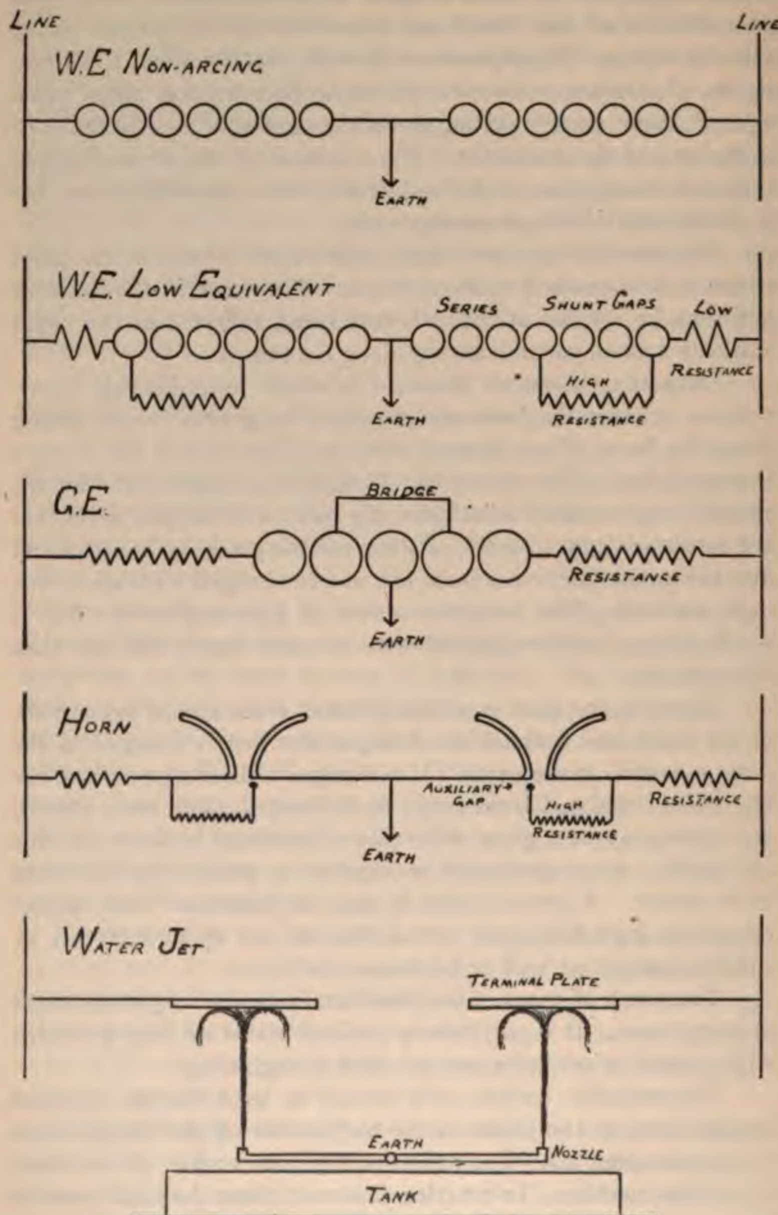
The remedy is to put choke coils in the branch at the point where it is connected to the network. The wave in the network will then be divided at the coil, part being reflected at this point and only a small part advancing along the branch.

Overhead Ground Wires—In many long-distance transmission systems the lines are protected by ground wires strung above the lines. These ground wires are connected to earth every thousand feet. The theory is: If lightning strikes the line the ground wire would be struck directly instead of the line wires that are insulated from ground. As the earth's potential is above and also below the line wires these can not be charged with static to a high potential. The inductive action of lightning on the line is much reduced, as the ground wire is much nearer the line than the earth is.

There is one case in which ground wires are of no service. If the earth and a cloud are charged, the line is charged to the same potential as the earth. If a disruptive discharge occurs, the line, being insulated from earth, is discharged much more slowly, and there may be a great difference of potential between the line and earth. Arresters would be required to protect the line from such strains. A ground wire is also no protection from strains caused by high-frequency waves that are set up in a circuit by sudden changes of load or by resonance.

The result of years of test has been favorable to ground wires in many cases. It is particularly noticeable that on lines provided with ground wires poles are not split by lightning.

Theoretically, barbed wire should be used for an overhead ground wire, as the points of the barbs draw off the charge from the surrounding air. The action is the same as that of the comb in a static machine. In practice, however, there does not seem to be any gain in the use of barbed wire. It is very difficult to string on poles, the points are far from being theoretical points, and the



LIGHTNING ARRESTER DIAGRAMS

wire is of a poor grade. These disadvantages more than offset the theoretical advantages. A good construction would be No. 8 B. & S. gauge E.B.B. wire, strung on glass insulators, and grounded every thousand feet. The two outside pins on the top cross-arm are sometimes used for ground wires, but as the construction is expensive and there is some difficulty in connecting the wires to ground, a single ground wire, either above or below the circuit, is more frequently employed. Glass insulators are used, so as not to subject the pole to any unnecessary electric strain from the line.

CONCLUSION —There is still much to be done before we can claim to have our lines perfectly protected. The engineers of the manufacturing companies have developed apparatus that operates successfully under ordinary conditions, but each transmission line is a separate problem, and can only be solved empirically. Complete records of static troubles and, so far as can be determined, their causes should be kept by the different power companies, to show how their apparatus is affected by the local conditions.

DISCUSSION

MR. DOW: This report on present methods of protection from lightning and other static disturbances was prepared by Mr. Robert S. Stewart, consulting engineer of the Peninsular Electric Light Company, of Detroit, and myself; and while his name is second on the title page, it should really be first.

In making this report there has been no attempt to go into detail theory or to recite the history of protective devices. It is, to the best of our belief, a statement of what may be considered the standard practice of to-day. We were unable to obtain, in sufficient time to put into print, the data regarding European practice that we should like to have incorporated, particularly with reference to the use of the water-jet arrester, referred to on page 242, which we find is common in the Swiss, Italian and southern French transmission systems. The water-jet arrester is obviously a leak of high resistance and of no inductance, and it consumes energy continuously. It appeared to us—although we did not include the statement in our printed report—that a water jet might be used to good purpose on many high-tension transmission lines as a special protection during thunder storms, in

much the same way as in certain railway plants the tank arrester is switched on during thunder storms. The effect is excellent and in conjunction with choke coils it seems to be the most thoroughly reliable method of protection. You will observe, of course, that its use involves a loss of energy of from three to ten kilowatts, depending on the voltage.

In the matter of the use of an overhead ground wire, strung on the transmission line, we will say that certain information reached us after this report was prepared; and while it does not add to the general statements here set forth, it is well to say that our recommendation of two outside pins for cross-arms—a tentative recommendation—I think would now be withdrawn in favor of the use of a single ground wire. We believe that in practice a single wire will do the work as well as two wires. On a three-phase transmission line the best place for the wire, if the wires are arranged symmetrically, is the neutral point of the triangle diagram; that is the point that would correspond to earth potential. Our recommendation would be to string one line wire on top of the pole, the other two wires in the equilateral triangular relation, and the ground wire in the centre of the triangle. We believe that a galvanized soft-iron ground wire, which when strung is carefully regulated to allow for the difference in contraction and expansion between iron and copper wire, will in many cases be invaluable; and will in all cases justify its erection where the line is of considerable length and the voltage high.

Regarding the horn arrester, we have not been able to get definite data. The theory given on page 238 is official; but we find that the use of the iron check pieces is dispensed with in many European plants, and we find there is no standard practice at all. The arrester seems to be rather a survival than a recent adaptation of the best means to the end in view.

We would recommend that the association again appoint a reporter—a committee is a somewhat unmanageable thing—who shall next year, and thereafter for a year or two, report on this subject, preparing a condensed report and annexing to it as an appendix information received regarding European practice, and such other information as may reach the reporter from time to time.

We would also advise that association members communicate

by letter to the official reporter any special experiences they may undergo in respect to lightning arresters and static disturbances. As is stated in the last paragraph of our report, there is still much to be done before we can claim to have our lines perfectly protected. Each transmission line is a separate problem. Even if two transmission lines be identical in their physical dimensions, yet they may be located in different altitudes or in different climates; and lines are seldom identical in dimensions. They in many recent instances include sections of cable, and when the conditions are thus complicated the problem is one that can only be solved by experiment. It is possible to put a great deal of money into protective devices and in that way to waste capital that could better be otherwise employed.

To sum it up—the only recommendation we can make just now is to see that the line is well protected according to the best present practice, and in this report the best present practice is described. If the apparatus to be protected is very valuable, or if continuity of service is of great importance, the expense will at least be justified; the hope being that less expense will be possible when our knowledge is more complete.

Mr. C. R. Maunsell (Topeka, Kan.): I ask if any cases have come to the knowledge of the committee of the puncturing of the lead lining of storage batteries by lightning on railway systems.

Mr. Dow: Not to my knowledge; but flashing across the battery terminals to ground has happened to my knowledge, and flashing across the damp outer surface of the tanks. That this will occur is quite likely indeed. The conditions in railway battery-rooms are often those that approximate the conditions of the tank arrester or water jet recommended as a protector. Lightning discharges will break across the wet surface to get away.

Mr. R. F. Hayward (Salt Lake City, Utah): Most of the members probably know that in Utah we have a number of miles of transmission lines running at 28,000 and 40,000 volts. There are, altogether, about 300 miles of 40,000 and 200 miles of 28,000-volt circuits running in parallel, and there are no thunder storms occurring within a range of 140 miles, north and south, that seem to miss these lines. I do not think that during last summer any one storm passed over our lines without striking something,

either directly or inductively. We put in all the lightning apparatus we can, not so much to protect our machinery and lines as to protect our consciences. We do not believe that it protects our apparatus, but we do like to say to the board of directors that we have taken every precaution that is known. We have about come to the conclusion—and this conclusion is based on our own experiences and upon the advice of the best authorities in the East, such as Mr. Steinmetz and Mr. Percy Thomas—that we must spread our lightning protection all over the line in the form of lightning conductors. Lightning tends to follow a line that is as non-inductive as possible, and a heavy discharge involving a large amount of current will not follow a single path very far, because the large amount of current in itself entails self-induction. We find that when a storm passes over us it will generally strike the lines and splinter a number of poles, shattering all the insulators on one pole and puncturing a number of insulators on other poles. The effect is seldom found far from the point where the lightning strikes. If the stroke is near the power-house, transformers are liable to be damaged by short-circuit, or terminals will be punctured and burned out. We have lost a number of transformers of the air-blast type which were wound in 1896 and 1897; but we have not lost any of the new windings with which we replaced the old type, although in a recent storm we had several terminals burned off. An arc will frequently jump from terminal to case over distances of five or six inches, both on oil-cooled and on air-blast transformers. This may shut down the plant for a moment, but does not do any other damage. Our recent experience encourages us to believe that modern insulation, whether on the air-blast or the oil-cooled type of transformer, is sufficiently high.

We believe that a ground wire on the line is, after all, the only practical protection against lightning. Mr. Honnold, our operating engineer, has devised a scheme that seems to be successful. When a thunder storm comes along, if we have not a ground wire on the line we ground one of the two circuits at each end of the line. In this way we have had several storms pass over without doing damage. This plan will not altogether prevent the lightning from striking the pole line, however, and if it strikes it is impossible to tell what may happen.

There is one point mentioned by Mr. Dow to which I take

some exception. I do not believe that the place for the ground wire is between the other wires. I would place it above; first of all, because I have a notion that during a thunder storm, just prior to the discharge that causes the trouble, there may be a certain amount of brush discharge to the line from the clouds, forming a preliminary breakdown path. I would place the ground wire as far above the line as possible. My reason for this is that when the stroke comes it may discharge to this wire and take the ground by a number of different paths without causing a short-circuit, whereas if the ground is in the neutral point of the main circuit a lightning discharge is almost certain to cause an arc, which will make a short-circuit. These sudden short-circuits are liable to set up low-frequency waves which travel to the power-house, pass through the choke coils, and are liable to break down the apparatus, whereas high-frequency waves would be checked by the choke coil.

MR. E. P. DILLON (Colorado Springs, Colo.): Those of us who are operating in Colorado have our troubles, especially in the zone in front of the foot-hills; we feel that lightning is probably more severe in this particular section than in any other part of the state, and we venture to say more severe than we have heard of in any other section of the country. It has required a good deal of attention, and study of the peculiar conditions of each system. In Colorado Springs we feel that we have a fair amount of protection now, although it is not absolute. We have distributed lightning arresters liberally at various plants and substations, but we have nothing on the line. We do not feel that the placing of lightning arresters on the line is warranted, the risk of having them on the line more than offsetting their advantage. We have no ground wire, but I think perhaps a well-constructed ground wire would probably obviate some of the difficulties we have had. Our triangle is not very large; 16-inch centres, with double circuits on the pole line. At three different times in the last two years we have had lines burn down directly in the middle of the span. It seems that the arc starts in some way between the wires, resulting from some kind of short-circuit, and runs along the line until it finds a weak point and burns the copper. Our copper is No. 1, with large engines behind it, with heavy flywheel capacity, tending to hold the arc long enough to burn the lines down. This has never occurred on junction poles,

where you would think the lightning would jump around, but invariably happens on the straight line.

Many of us feel, I believe, that our static disturbances are most likely to come in the summer time—during the summer season. Last winter, in December, due probably to a heavy wind that was blowing at the time, we had some exceedingly severe discharges from the lightning arresters; they appeared to be heavy enough to destroy some apparatus had the lightning arresters been in service. Another peculiar thing here is that with lines in extremely high altitudes—above 11,000 feet—the disturbances are much less severe; they are practically unknown on extremely high lines, while the valley lines suffer severely. I think this is due to the fact that the clouds come down so low that there is not a chance for much difference of potential between the clouds and the earth. I have been on high ridges during storms, and you can feel a tingle all through your body, like a slight electric shock. It seems to me that at these points there is a constant discharge between the clouds and the earth and no opportunity offered for a great difference of potential to be formed and then discharged in the form of a heavy bolt. But this will not hold true in all cases, because in the mountains immediately around here, while the altitudes are not very great, the disturbances are very severe and heavy, especially on the mountain railway lines.

I would call your attention to the arrangement of arresters in the Pike's Peak Hydro-Electric plant, which you will probably visit, but with which plant I am not connected. There they have installed a combination of spark gap and high-resistance arresters and the water tank. These have been in use only a short time, but have carried them through three or four severe storms and no unpleasant results have followed. They take care of the discharges very nicely, and they were seen to work a number of times. I think that is a very good combination, although somewhat bulky.

In Colorado, we are not very partial to the use of a barbed-wire ground. A well-constructed ground wire no doubt has its advantages, and is certainly good in theory, but the barbed ground wire, due to the uneven quality of the wire in twisting, has been known in many cases in the West to break and cause more serious line trouble than any lightning disturbances. A

great many of the operators in this country prefer to take chances on what has been designed in the way of lightning protection rather than to put in the barbed ground wire. I think a well-made steel wire of good tensile strength would, no doubt, give very good protection and help out the regular arrester. In our main generating station, just out of Colorado Springs, which we installed, there was considerable experimenting with lightning arresters, and we finally went over to the high-resistance arrester in combination with the spark gap. They did not completely take care of the trouble and about two years ago we put them up in a combination, or series parallel, arrangement, giving the discharge a straight path to ground, and split through the arrester. I am glad to say that up to date, ever since that change was made, we have not had any discharges on our switchboard. It appears to be a very successful arrangement.

MR. GEORGE R. STETSON (New Bedford, Mass.): While in the far East we hardly expect to carry the matter of lightning protection to the extent they do in the West, we have our troubles, which are perhaps as serious and as difficult to account for. In the station I had the care of last December, after having run direct current for a good many years and an underground system of transmission for four or five years, an epidemic broke out among our motors which raged for several weeks and in two weeks destroyed more motors than had been destroyed in all the fourteen previous years of operation of our plant. This was an unexpected epidemic with us, and we went to work and treated it as fast as possible but have not got over it yet. It was a static manifestation. Previously to this we had never found it necessary to make any particular provision for the care of our motors, but at this time the motors within a radius of three to five miles were punctured, one after the other, some being served by the underground and some by the overhead system. The puncture was very much in the nature of a lightning puncture—generally on the armature. At first we were able to repair the armatures within a reasonable time and without much inconvenience to our customers; but it finally went beyond the motors outside and came into the generators inside, and that was more serious. The singular feature of the matter was the manifestation at this particular time. We immediately went to work to take care of the motors, as far as possible, by putting up

lightning arresters and kicking coils, and seemed to have conquered the trouble to quite an extent; but we occasionally have a manifestation now, particularly if we have not taken proper care of the motors.

I relate this experience so that if any of our members feel that they are pretty safe about static discharges they had better not be too sure. These discharges take place under peculiar conditions; usually such conditions of atmosphere as contribute to a high electric potential, a condition of atmosphere, clear, such as would make electric transmission easy. We set up a Bristol gauge, putting in the proper resistances, and the manifestations on that gauge were very interesting. The gauge sometimes failed to be large enough to take the limit of the stroke, but it kept things up very lively and painted the index pretty nearly all over, and you could see the flash coming from the work of that needle. So you must be prepared not only for lightning, but for static disturbances. In this case it seemed very singular to us that after so many years of repose we should be kicked about so vigorously by static troubles during this one season.

MR. HONNOLD: I would emphasize the importance of the appointment of this committee and the necessity for it to begin its work at this session. In this way we can get data from the operator in the field and the engineer in the factory. The committee should gather the investigations of the operators in the field in conjunction with the statistics of the engineers in factories, and I think that in two or three years we can overcome these troubles. In Utah we are going after this subject vigorously this year and are getting some interesting data that are up to date. We have had lightning almost continuously since the first of March of this year. We are experimenting with the present types of arrester and in conjunction with these arresters we are experimenting with the grounded circuit. We are experimenting with the total number of gaps in series in conjunction with the resistances that the companies furnish; the Westinghouse resistances and the General Electric resistances. We have had General Electric resistances go all to pieces and the Westinghouse resistances have been burned up. In both cases the arrester is made temporarily inoperative. That must be gotten around in some way, and, although we have not put it in operation yet, I think the Pike's Peak scheme of the tank or water-jet resist-

ance in series with the gaps will do the business. I believe we shall have some interesting data on that point later.

We are experimenting on the gap proposition by short-circuiting some of the gaps with fuses across from five to fifteen gaps, and we crowd the limit up to the sparking limit over the gaps. Of course, in conjunction with these experiments, we keep the test papers, making exact records from these test papers; the kind of discharge being indicated, the size of puncture, and different points being covered, we expect to get some interesting data from these test papers. We find with these test papers—we keep them at each end of the spark gap; that is, at the top and bottom—that we sometimes have a heavy discharge on the bottom paper and none at the top, which is a very peculiar thing. Such things are hard to explain—how a puncture could occur and show on the bottom paper and not on the top paper. We shall probably dig these things out and know something about them at the end of this year.

MR. HARTMAN: If I understood Mr. Dow's suggestion as to the location of the ground wire, it was that on a two-phase, four-wire system the wire should be located at the centre of the square formed by the four lines, and that in the three-phase system it should be located in the centre of the triangle. I think there would be a practical objection to that in the fact that in a high-tension transmission it would virtually reduce the distance between the wires, and in an ordinarily low-tension transmission it would subject the lineman to very serious danger in making connections to the lines.

MR. JACKSON: Regarding the static conditions on transmission lines, some three or four years ago I made a somewhat complete examination of the line in northern Italy, and at that time they had the jet static arresters in use. They were very much troubled by attacks of static disturbances on their 20,000-volt generators, and they were frequently shut down, as I was informed, on account, not of the lightning particularly, but on account of the static going through the insulation of the 20,000-volt machines. They then installed jet static arresters, and I think the arresters had been in about six months. I was informed at the time that since the installation of the jet arresters—the water-jet arresters—they had had no trouble from static effects. It would be very interesting if there is any one in the audience

who could bring that information more nearly to date; to know if the action of the jet arresters was thoroughly satisfactory up to the time they were last heard from.

Mr. Dow: Taking the questions raised in the discussion in the reverse sequence, so far as possible, I will endeavor to give further information regarding the subject. In the matter of the action of the water jets on the Valtellina line, through the courtesy of some correspondents of ours, who ask that they be not quoted—I think the request has its base in their modesty only—we have been furnished with recent information regarding this line. The water jets are still satisfactory. Your reporters believe that the water jets—I think I so stated in my brief of this report—form the most comprehensively reliable arrangement that we have just now for protection against either lightning or static discharges when installed in connection with choke coils. The function of the choke coil is to locate the point of discharge for any excessive voltage. The objections to the jets are, first of all, the things are sloppy; next, that they take energy. Because of this taking of energy we made, verbally, the recommendation that they be held as emergency devices where possible, and upon the appearance of static discharge on the line the water jets be turned on. At 20,000 volts the amount of current that one of these jets will take is enough to do quite a little work toward earning dividends for the company. There would be quite a loss through their constant use, and we do not recommend that they be left on the service continuously.

With reference to Mr. Hartman's remark, and in reply to Mr. Hayward's comment in regard to the position of the ground wire. The centre of the square on the two-phase transmission should be at earth potential. In a two-phase transmission the geometrical centre of the square is the theoretically correct position of the ground wire, as, likewise, is the centre of the triangle on a three-phase transmission; for the reason that these positions are theoretically at earth potential if the line is insulated, and are absolutely so if, as is usually the case with Y-connected step-up transformers, the central point of the Y is positively connected to the earth. If the distance between the two-phase conductors, or the delta distance between the wires of the three-phase circuit, is correct for the voltage between the wires, then the distance to the ground wire will of necessity be correct. That admits of mathematical demonstration.

As regards the danger on low-voltage transmission systems—on lines where a lineman can with the current on make connections, the ground wire is hardly necessary. On the lines principally under consideration, where such devices are required, it is criminal to send a man to do work when the lines are alive. The matter put forward by Mr. Hayward and Mr. Dillon—also the matter of arcing between lines, the wires being spaced thus and so—the placing of another wire in there making it difficult to work on the pole, *et cætera,* the point is well taken; but we have not stated any distances, and the distance from the ground wire should be regulated by the same rules as the distance between the other wires. If the distance between the other wires of the delta three-phase transmission is now ample electrically, the distance to the ground wire in the centre of the triangle will also be ample. Mechanically, it may be desirable to separate the wires further; in fact, with our tendency toward long spans it is necessary to spread the wires more and more beyond what constitutes our present practice. The Niagara Falls system started in with some fourteen inches between the wires and they more than doubled it afterward, and the tendency is to still wider spacing.

Answering Mr. Hayward's remark as to placing the ground wire above the transmission lines instead of among the wires—that point is referred to on page 241 of the report. The theory is that as the earth's potential is above and also below the line wires these can not be charged with static to a high potential. The fact is exactly what Mr. Hayward points out. The preliminary brush discharge, or discharge of the atmosphere, is taken by the ground wire. To all intents and purposes, a variation of the vertical position of the ground wire within two or three feet is immaterial. But if the ground wire is nearer to one of the transmission wires than to any of the others, when a stroke takes place and the ground wire discharges instantly, as it were, the wire nearest to the ground wire on the transmission will be very highly stressed relatively to the ground wire. There will be stress between the wires of the transmission and there will also be great stress between the closest wire and the ground wire. Under these conditions, which are pointed out in paragraph four of page 241, the position of the ground wire is better in the middle than above. We can not consider the gradient of potential between the clouds and the earth as a straight line. I may say it is not entirely theory

that causes us to recommend this position of the ground wire; it has proved to be good in practice on a certain Michigan line. The fact, which Mr. Hayward has noticed, of the jumping across the transformer terminals is common. It indicates that he should have static discharges across the lines and indicates a difference of potential between the two or three wires of the system, which a non-inductive resistance, such as the water jet, will take care of. A jump represents merely an equalization of the temporary stresses between two wires of the three. The obvious remedy is the providing of a good non-inductive path between the two wires.

Mr. Stetson's experience with punctures causes me to suspect that he had a reaction from his machines. I fancy that when the short-circuits occurred the machine went over, or there was a short-circuit of some device on the line; and a quick breaking of a short-circuit puts the worst stresses on the line. Mr. Stewart calculated, at my request, the effect of a short-circuit on a certain transmission line we are now building in Michigan. The voltage between the wires on the short-circuit will, by calculation, be in that case over 80,000 volts. We are therefore not at all anxious to start short-circuits, nor to break them too rapidly.

The point made by Mr. Dillon, that the blowing of wind across the line on the upper levels may charge the line with static, is also well known. It is mentioned on page 235 of our report. The most aggravated case of that is a sand storm. I believe our telegraph friends would tell us that on the Western Union lines, along the route of the Santa Fé railroad, across New Mexico and up through Arizona, a sand storm puts them out of business very quickly, and the only remedy is the application of non-inductive ground circuits from all the wires to the ground. The conditions are the same as in our case, although they do not have the same voltages to handle.

The point is made that barbed ground wire is not good. We recommend flatly against it in our report. I want to say that the distinction between static and lightning is not essential. You refer to lightning when there is a thunder storm, but there are differences of potential on hills and in valleys—a different potential between one point on the line and other points on the line—that are exactly the same in their laws and yet they are not the terrific discharges that we recognize and call lightning. The laws are the same and the protection is the same. The discharges from

our own apparatus and from our own lines which follow the break of a short-circuit are of the same order, except that they are of lower frequency, and the protection again is the same.

I can not make it too strong that the provision of low-resistance, non-inductive paths to ground and between lines is the perfect protection. It is only a question as to whether or not we can stand the losses of energy that those low-resistance, non-inductive paths require.

THE PRESIDENT: We will now take up the paper on *The Nernst Lamp—Its Present Performance and Commercial Status,* by Mr. E. R. Roberts, of Pittsburg.

The paper was presented by Mr. Roberts, as follows:

THE NERNST LAMP—ITS PRESENT PERFORMANCE AND COMMERCIAL STATUS

The days when the Nernst lamp excited interest and was regarded more as a scientific novelty than as an article of real commercial merit are long since past. It now stands before you as a "live" business proposition. Presuming, therefore, that everyone interested in the lighting business has considered it his duty to make a personal study of the Nernst lamp and has already done so, we will not at present devote time or space to a detailed description of the lamp and its characteristics, but will pass on to those phases of the subject which are implied in the above title.

Efficiency

The Nernst Lamp Company has, at this writing, just completed a series of photometric and life tests on its standard product, and it is partly the purpose of this paper to present the results obtained as the most complete and reliable data of the kind yet given out by the manufacturers.

The candle-power measurements were made with a standard disc photometer riding on a graduated 10-foot bar, carrying at one end a 100-cp standard incandescent lamp and at the other end a single mirror attachment for obtaining mean spherical intensities. As shown in Figure 1, the lamp is supported by an arm *A*, which may be rotated in a vertical plane about the axis *B*, so that the glower of the lamp describes a circle whose centre is the centre point *C* of the mirror. The motion of the arm *A* is transmitted through gears *D, E, F*, to the mirror, causing it to rotate about the axis $C - C'$, so that it always remains in the same position with respect to the light source, and, since the lamp may be rotated about its vertical axis, the intensity in any direction may be measured, allowing for loss by mirror absorption. With this style of photometer there is only one mirror to correct for; the intensities of the standard and the illuminant are of the same order of brightness, and there is no marked difference in the respective distances of the standard and illuminant from the photometer screen.

In the conduct of this test, the manufacturers did not, of course, wish to deceive themselves, and, knowing the characteristics of the Nernst lamp, every precaution was taken by them to provide proper and practical conditions. The instruments used were regularly calibrated by means of a standard potentiometer set with a standard cell, which is, itself, periodically checked at the National Bureau of Standards. All photometer readings were taken by an experienced operator, who, by comparative tests, has proved to be accurate and reliable. To approximate actual conditions in the life test, the lamps were operated on a circuit having a regulation of five per cent, which was supplied through an automatic switch which operates every three

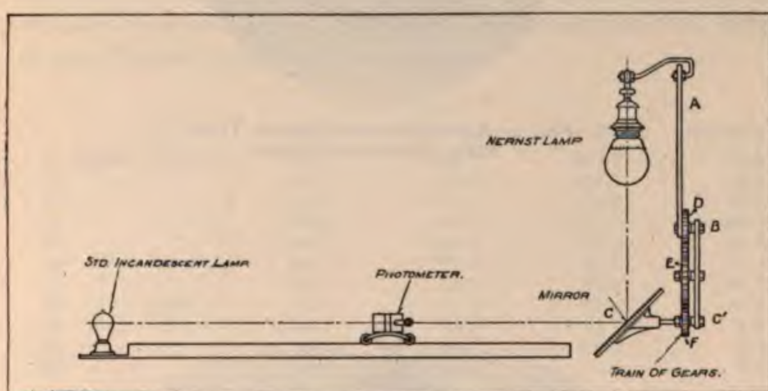


FIG. 1—DIAGRAM OF PHOTOMETER

and one-half hours, throwing the lamps "off" and allowing them to remain so a sufficient length of time for the lamps to reach a "cold" state before the current is again established.

While there are several different styles and combinations of glassware used with the Nernst lamp, the clear and diffusing globes are to be regarded as more standard, and the other styles as more special, in their shape and usage. Sufficient time was not available in which to make a general investigation of all the different types of glassware, and, since the clear globe is not generally used, it was thought best to confine our efforts to a test with a diffusing globe of the sand-blasted type, believing this would be of most practical value.

FIG. 2—NERNST LAMP (INDOOR TYPE) WITH DIFFUSING GLOBE

FIG. 3—NERNST LAMP (INDOOR) WITH SHADE AND HEATER CASE

The relative effect produced on the light distribution of the lamp by the use of different glassware is shown in Figure 6.

To obtain an average and eliminate to some extent the effect of inequalities in the density of the globes, each lamp was given three separate tests, using a different globe each time; globes of average density being selected. Of the tabulated figures and curves given below, therefore, each represents the average values for three different globes. In addition to a previous life of four or five hours, each lamp was allowed to run on normal voltage until it became thoroughly heated and the wattage reached a constant value before the spherical distribution was taken. The time required to reach these conditions varies from one-half to three-quarters of an hour. The average readings obtained from the six, four, three and one-glower, 220-volt, lamps in the different zones were as follows:

TABLE No. 1

Zone	Six-Glower	Four-Glower	Three-Glower	One-Glower
90 degree below hor.	472.7	314 3	200.6	64.5
75 " " "	401.1	246.9	172.3	54.6
60 " " "	419.6	269 9	164.9	48.7
45 " " "	358.3	222.8	151.3	43.9
30 " " "	296.7	191.3	128.3	35.0
15 " " "	231.8	147.8	97.5	27.0
0 " " "	126.2	93.2	67.3	21.7
15 " above "	76.3	58.1	45.9	11.4
30 " " "	50.1	38.1	23.3	5.9
45 " " "	35.2	25.3	15.6	4.4
60 " " "	23.9	18.1	.....	2.9

Besides being the average for three different globes, each of the zonal candle-power values in table No. 1 is the mean obtained from seven observations taken 30 degrees apart, in the same horizontal plane, as the lamp is rotated on its axis (see Figure 7). Theoretically, the horizontal distribution about the lamp at any one zone should be regular in form, and it might seem that the method, which has been used in the past, of obtaining a mean from a series of readings taken in a single quadrant, 0° — 90°, (Figure 7) would be accurate. However, the sample curve from the three-glower lamp shows that (due probably to unsymmetrical mounting or warping of the glowers) such is not the case, and that the mean of quadrant 0° — 90° is four per cent less than the mean of quadrant 0° — 270°. For the same reason it is even less accurate to use the mean of the maximum and minimum values only.

The results contained in table No. 1 are also given in plotted form. (See Figures 8, 9, 10 and 11.)

The average mean spherical and hemispherical efficiencies calculated by the planimeter method from table No. 1 are given in table No. 2; which may be regarded as a summary of the foregoing tests. The corresponding figures for multiple enclosed-arc lamps are also given, to show how favorably the Nernst lamp

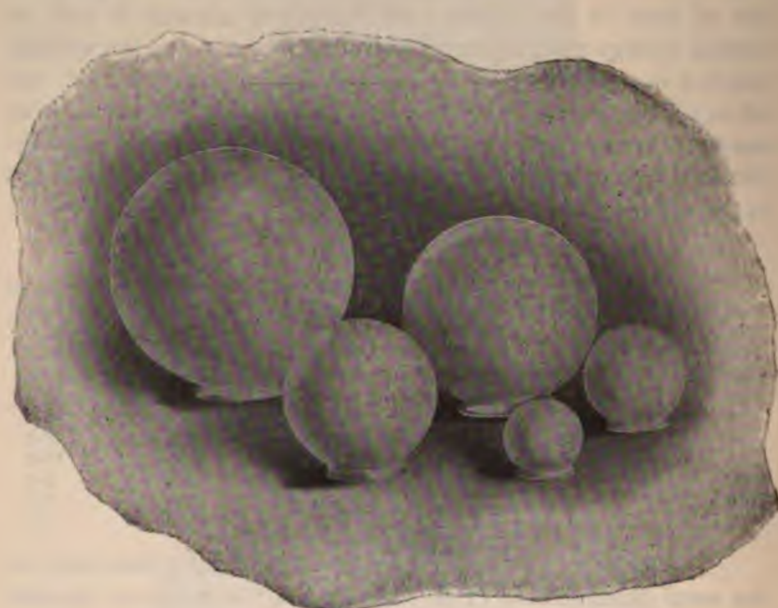


FIG. 4—SAND-BLASTED GLOBES

(in the multiple-glower types) compares with the arc lamp in efficiency.

TABLE No. 2

Lamps	NERNST LAMPS				ARC LAMPS*	
	Six-Glower	Four-Glower	Three-Glower	One-Glower	A. C. Multiple	D. C. Multiple
Voltage	220	220	220	220	110	110
Wattage....................	521	349	263	88	417	539
Mean spherical C. P.........	176.4	115	77.1	22.5	140	182
" hemispherical C. P...	297.2	189.1	124.5	36.3	167	239
" spherical efficiency...	2.95	3.03	3.45	3.92	3.02	2.96
" hemispherical eff.....	1.76	1.84	2.11	2.43	2.53	2.25

* Arc lamps fitted with opal inner and clear outer globes.
Nernst lamps fitted with sand-blasted globes.
Arc data taken from Prof. Matthews' report to N. E. L. Association, May, 1903.

In the above it is also clearly shown that the efficiency of the lamp steadily increases with the number of glowers, owing to

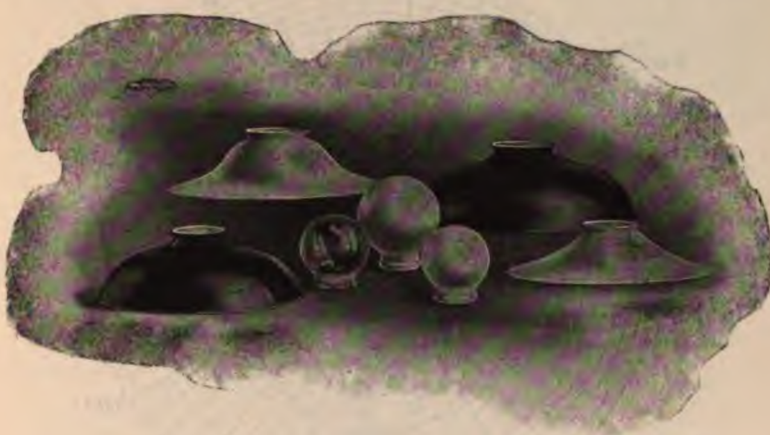


FIG. 5—SHADES AND HEATER CASES

the negative temperature coefficient of the glower material and the fact that the several glowers tend to heat each other; this

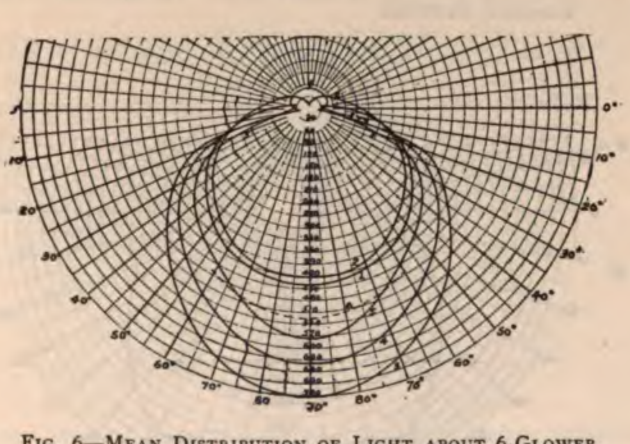


FIG. 6—MEAN DISTRIBUTION OF LIGHT ABOUT 6-GLOWER LAMP WITH DIFFERENT GLASSWARE

mutual heating effect being, of course, proportional to the number of glowers.

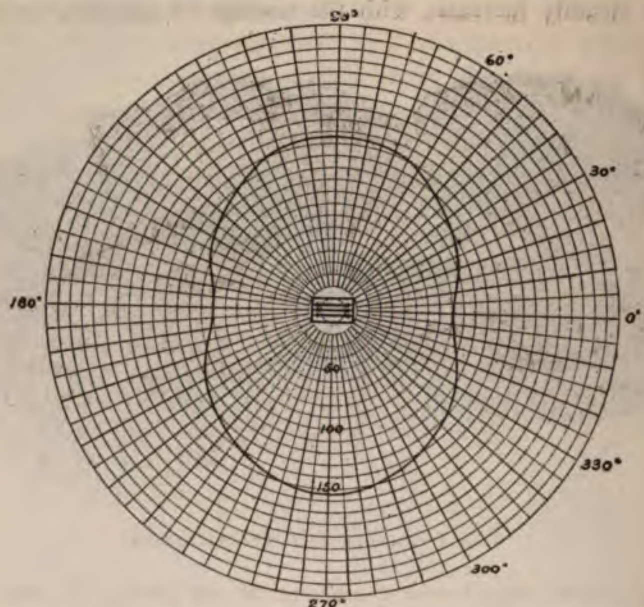


FIG. 7—AVERAGE HORIZONTAL DISTRIBUTION OF LIGHT ABOUT 3-GLOWER LAMP 30 DEGREES BELOW HORIZONTAL PLANE THROUGH GLOWERS

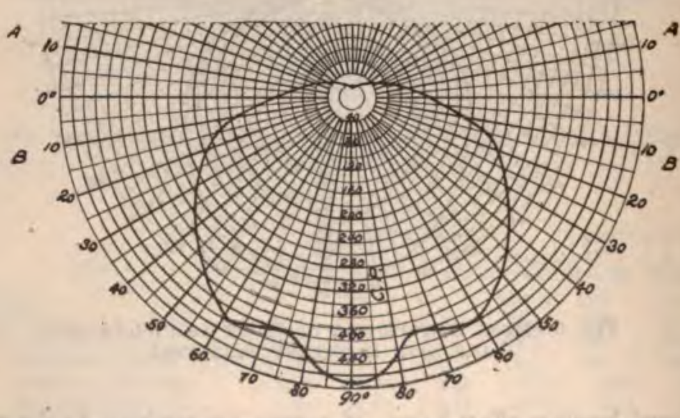


FIG. 8—AVERAGE MEAN DISTRIBUTION CURVES OF THREE 6-GLOWER LAMPS WITH 8-INCH SAND-BLASTED GLOBES

Life Test

For a life test, the four-glower lamp was selected as being well representative of the other standard units, and the following

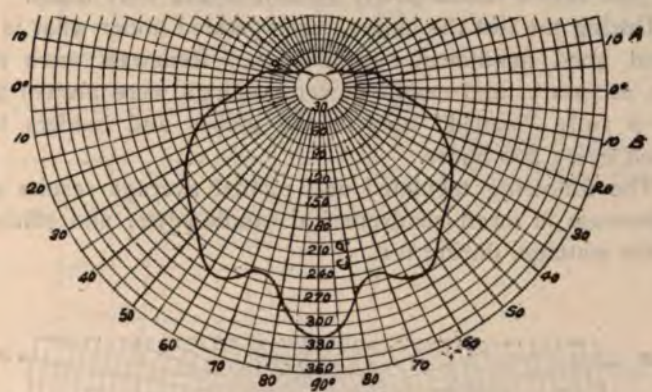


FIG. 9—AVERAGE MEAN DISTRIBUTION CURVES OF THREE 4-GLOWER LAMPS WITH 8-INCH SAND-BLASTED GLOBES

results will represent the average performance of five different four-glower units, equipped with diffusing globes of average

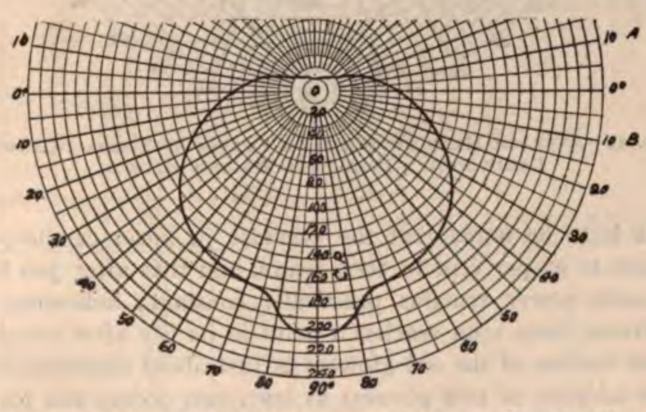


FIG. 10—AVERAGE MEAN DISTRIBUTION CURVES OF THREE 3-GLOWER LAMPS WITH 6-INCH SAND-BLASTED GLOBES

density. The lamps were run on a 60-cycle, 226-volt circuit which, as previously stated, was interrupted every three and

one-half hours. Complete spherical distributions of candle-power were taken at 0, 25, 100, 200, *et cætera,* hours life, the lamps being allowed to operate on normal voltage for 45 minutes' time just before candle-power measurements were made.

During the test the lamps were operated under what is considered good maintenance conditions. Renewals were made when necessary, and candle-power readings were always taken with a fully "loaded" holder; the globes and holders being cleaned every 200 hours.

The following tabulated and plotted average results show the decrease in mean hemispherical candle-power and efficiency, also the wattage, during test.

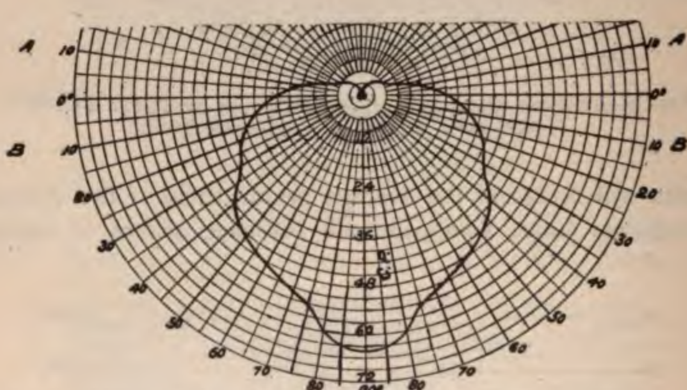


FIG. 11—AVERAGE MEAN DISTRIBUTION CURVES OF THREE 1-GLOWER LAMPS WITH 4-INCH SAND-BLASTED GLOBES

It is to be noted that the decrease in mean candle-power amounts to 22 per cent in 1000 hours, and that after 300 hours the candle-power remains practically constant; indicating that the Nernst lamp soon reaches a point in its life after which the further decline of the old glowers is just about counterbalanced by the addition of new glowers as burn-outs occur; and for this reason it is to be classed as a constant efficiency lamp under good maintenance conditions.

The decrease in wattage shown is undoubtedly due to the fact that the resistance of the glower gradually rises during its life. Before being used, the surface of the glower presents a

TABLE No. 3

Life	Mean Spherical C. P.	Mean Hemispherical C. P.	Watts	Mean Spherical Efficiency	Mean Hemispherical Efficiency
0	105.6	178.94	349.3	3.31	1.95
25	108.5	181.01	352.5	3.25	1.95
100	97.65	164.31	344.9	3.53	2.10
200	94.25	157.06	340.2	3.61	2.17
300	86.81	143.19	335.4	3.86	2 34
400	88.07	146.67	336.4	3.82	2.29
500	86.47	143.97	338.6	3.92	2.35
600	84.89	142.11	329.4	3.88	2.32
700	87.44	147.34	333.9	3.82	2.27
800	87.00	145.00	342.2	3.93	2.36
900	82.24	129.69	316.0	4.37	2.44
1000	84.37	140.5	319.2	3.78	2.27

FIG. 12—LIFE CURVES OF 4-GLOWER NERNST LAMP

smooth, white chalk-like appearance. After having been in service 500 hours or more its surface is rough and crystalline in appearance. It is this change in the structure of the glower, from an amorphous to a crystalline state, that is supposed to cause the rise in its resistance. This increase amounts, on an average, to five per cent in 500 hours.

During the above test, 12 of the 20 glowers started had to be renewed. No heater burn-outs occurred. Assuming an average life of 1000 hours for the glowers remaining in the lamps at the end of the test, an estimated average glower life of 800 hours is obtained, notwithstanding the frequent handling that the lamps were subjected to during the candle-power test. Aside from these rather meager life data, however, a separate maintenance test has recently been made on the four-glower lamp. Six lamps were run for a period of 2250 hours, on the same circuit used in the preceding life test. From this the following data were obtained:

Duration of test in hours	2 250
Number of four-glower lamps on test	6
Total number of glower hours	54,000
Number of glower burnouts	34
" " heater "	8
" " ballast "	0
" " heater porcelains broken	1
Average glower life in hours	1 600
" heater life (calculated)	3 375

Characteristics

The effect of voltage variation on the Nernst lamp is clearly shown in table No. 4 and Figure 14; the curves being plotted from the table in percentage values:

TABLE No. 4

Volts	Current	Watts	Mean Candle-power
180	.80	147	32.4
190	.98	187	53
200	1.19	238	90.5
210	1.40	295	144
220	1.55	341	185
230	1.63	374	201
240	1.64	393	203
250	1.65	413	207
260	1.69	440	220

This test, like the preceding ones, is of recent date and represents the average performance of three four-glower lamps, which

unit in turn is representative of the other standard and most popular units.

Contrary to the usual custom in obtaining a lamp characteristic, of starting at the lowest point on the curve and passing through the normal to the highest point, it was thought best, in the case of the Nernst lamp, with its sluggish temperature characteristic, to start at normal and gradually lower the voltage, taking readings at regular intervals; then bringing the lamp back

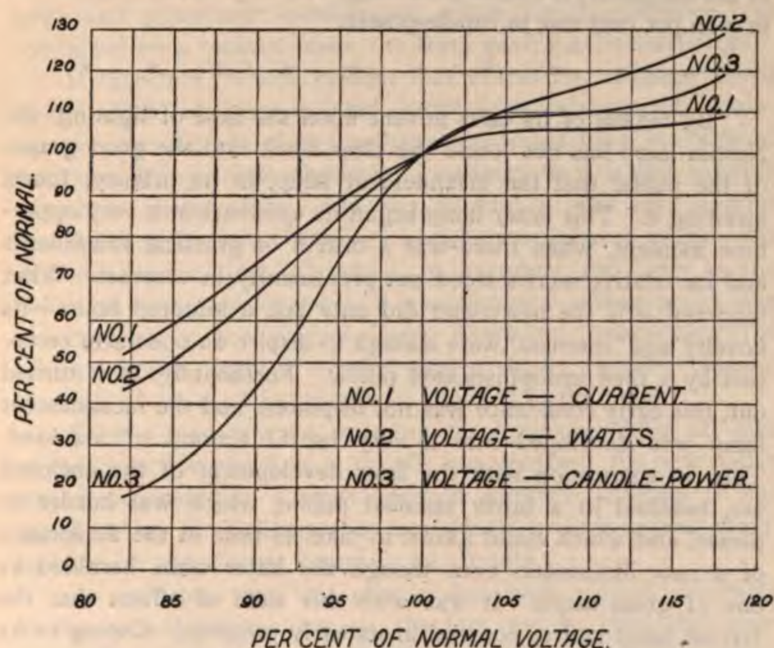


FIG. 13—PER CENT OF NORMAL VOLTAGE

again to normal. After giving it sufficient time to attain its normal wattage value, readings are taken at intervals on a rising scale from the normal point up to the highest. Obviously, this method more nearly approximates actual conditions, since the lamp in practice is subject to a drop or rise in voltage from normal. It has been ascertained that the mean intensity of the lamp (fitted with a sand-blasted globe, as these were), at 30 degrees below the horizontal corresponds very closely to the true

value of the mean lower hemispherical candle-power. This fact, which is borne out by the results in tables No. 1 and No. 2, was made use of in the characteristic test to save time, and the figures given are approximate values of the mean hemispherical candle-power. These, of course, serve equally as well as the true values in obtaining a percentage comparison.

It is to be noted from the curves that while a drop in voltage of five per cent below normal causes a decrease of 25 per cent in candle-power, the same percentage rise in pressure only results in a 10 per cent rise in candle-power.

* * * * * * * * * *

By reason of its later advent upon the field of lighting, the Nernst lamp has not found the clear track into the good graces of the public that the incandescent lamp, in its infancy, found awaiting it. This latter lamp began its existence at a very opportune moment, when there was a dearth of practical illuminants and its relative merits stood out prominently in contrast. What mattered it if the newcomer did only last a hundred hours—its novelty and "cuteness" were enough to inspire an open-arm reception by a then unsophisticated public. Fortunately, as it turned out, this early confidence was not ill-placed, and the incandescent lamp was developed into a very useful servant of mankind. This, in connection with the later development of the enclosed arc, resulted in a fairly satisfied public, which was harder to please, and which could afford to take its time in the acceptance of a new illuminant, even though the latter came heralded as one of great merit. It was with this state of affairs that the Nernst lamp had to contend in its early progress. Owing to its demonstrated advantages of efficiency and "sunlight" quality, however, this first shyness is gradually and surely being overcome, and is being replaced by growing confidence and, in many quarters, enthusiasm regarding the future of the lamp.

It may here also be said that the early advance was further impeded by the reputation which the lamp got, in many quarters, of being a delicate device requiring expert attention and fit only for laboratory usage—a reputation that was entirely chargeable to the early sales policy, in force during the years 1902 and 1903, of using the electrical supply dealer and jobber as a medium for the introduction of the Nernst lamp. While these dealers agreed

to give full maintenance instructions to the lamp purchasers, this was not in all cases consistently done, and Nernst lamps were sold apparently with utter disregard of conditions. In this way thousands of lamps were scattered about the country among small users, who, after "fussing with the thing awhile," as they put it, became disgusted and consigned the lamp to a high shelf. With this experience, it is not likely that the opinion of such a customer would serve as a creditable testimonial.

Opposed to this, however, was the fact that, in a number of large and prominent installations, where the maintenance was conducted on a rational basis, the lamp gave good satisfaction.

It therefore became evident that unless the company could limit its field to large isolated installations, with private maintenance, the success of the industry depended upon the sale of the lamp being made through a medium that would provide systematic maintenance. On this account it was only natural that the central station lighting company was selected as the most desirable agency through which to introduce the lamp to the public at large. Accordingly, a complete new selling policy was inaugurated by the Nernst Lamp Company, establishing the central station, instead of the supply dealer, as the channel through which the lamp would be supplied to the public.

With a view toward relieving the light-user from all care of the lamp, for which he is usually not prepared, the new policy was incorporated in a central-station contract, wherein it was specified that the lighting company should provide proper maintenance for the Nernst lamps on its circuits.

As evidence that this change has been viewed favorably by the central-station interests, the fact may be cited that prior to April 1 of this year 210 lighting companies, including nearly all the large ones, have accepted the new contract and are finding the lamp to be a valuable ally in their business. Another fact in this connection is that the total sales for the first quarter of 1905 show an increase of 155 per cent over the corresponding figure for the same period of 1904.

The following table, giving the total number of glower units placed in service during the year ending April 1, 1905, may be of interest in showing the respective percentage demand existing for the different units; and that, thus far, the three-glower lamp is the most popular of all.

TABLE No. 5

Type	Equivalent Glower Units*	Per Cent of Total
6-glower	13,446	22.5
†4-glower	4,936	8.0
3-glower	25,515	42.0
2-glower	5,574	9.2
1-glower, 220-volt	6,493	10.7
1-glower, 110-volt	1,858	3.1
"Baby"	2,754	4.5
Total	60,576	100

* One six-glower is equivalent to six glower units, etc.
† This type was not on the market prior to October 1, 1904.

Maintenance

While the Nernst lamp properly belongs in the class of incandescent lamps, from the maintenance standpoint it is more akin to the arc, owing to its general structure; the three main structural parts of the Nernst, viz., the lamp body, holder, and globe, being analogous to the corresponding parts of the arc lamp. From this point of similarity alone, it would seem evident that the maintenance of the arc and Nernst systems is much the same. In the arc system the lamps are periodically inspected, globes and shades cleaned, carbons renewed and occasional faults or failures of the internal mechanism repaired. Likewise, in the Nernst system the requirements are cleaning glassware, replacing burned-out holders and renewing an occasional ruptured ballast. The extra labor necessary for the subsequent repair of Nernst holders at the station may be counterbalanced by the extra time required in the arc system for more frequent inspection tours; the average life of the glowers being about ten times that of the carbons.

As a matter of fact, the Nernst maintenance system recommended for central stations is quite similar in its main features to the arc maintenance system of the New York Edison Company, as described in a paper presented at the 1904 convention of this association. Reference might also be made to various papers and articles in the technical press on incandescent lighting, in which it is shown that systematic maintenance is also necessary for good results in this system.

The statement occasionally heard coming from inexperienced persons, that the Nernst lamp requires *skilled* labor for its successful operation is only true in the sense that arc trimmers are

skilled, and is false if intended to convey the idea of *expensive* labor. The actual work of repairing is so simple, owing to the careful provision made in the lamp design for easy renewal, that a boy or girl can, in a short time, acquire the necessary skill.

The maintenance bureau operated by the Nernst Lamp Company in the Pittsburg district—the largest organization of this kind in the amount of business handled—has in its employ one young man acting as foreman over a corps of five inspectors, and a girl who does the holder-repair work. This force easily handles the entire maintenance of the 7000 glower units operated by the bureau; the territory covered being within a radius of twelve miles. The itemized and total average cost per glower-month for the recent winter months, December, January and February, is as follows:

	Cost per Glower-Month
Labor	3.71 cents
Expenses (car-fare, etc.)	.80 "
Material	5.05 "
Total	9.56 cents

This cost per glower-month is, of course, somewhat higher than the yearly average would be, on account of the long burning hours of the winter season.

From the above, the estimated cost per kilowatt-hour, assuming eight hours' burning per day, is 5.2 mills; which figure agrees closely with the average cost reported by a number of companies who use the lamp on a large scale and carry out the maintenance on a practical basis.

Aside from this, however, there remains the fact that out of the 210 lighting companies previously mentioned 73 per cent of these (including the largest) are supplying the Nernst lamp on the same free-renewal basis as that upon which they supply arc and incandescent lamps. This would seem to be the most practical proof that the cost of Nernst maintenance, in comparison with that of the arc and incandescent systems, is at least not prohibitive.

Application

The chief value of the Nernst lamp to the public, and its real field of usefulness to electric-lighting interests, becomes evident in a brief review of lighting history. The competition

between gas and electric illuminants that began with the birth of the carbon-filament lamp about twenty-five years ago has since been one of varying success to both sides. The early incandescent lamp, coming into competition with gas burners of the fishtail and Argand type, proved itself so much superior that for a time it seemed as if the incandescent as a small unit, with the open-arc lamp as a large unit, would sweep the field clear for electricity. As you know, this sweeping process was, however, brought to an abrupt halt by the later introduction of the Welsbach gas mantle. Since that time honors have been about even between the gas mantle burner and the incandescent lamp, and by reason of the respective advantages of cheapness in the one and convenience of the other, the spread of electric service has been more or less confined to the richer and more enterprising classes, leaving the larger and more common field open to the inroads of gas lighting.

In addition to the lower operating cost, the gas units, especially those of the multiple-burner type, were of a more suitable intensity for commercial service than were either of its competitors. True, much has been done, both by the electric lamp manufacturers in the improvement of its product and by the lighting companies in perfecting their service, toward warding off the encroachments of gas. Yet, with the arc lamp barred to a great extent on account of its size, and the incandescent handicapped both in size and efficiency, the odds have been great, and the need of a more efficient illuminant, in sizes to compete with the different gas units, has been thoroughly appreciated by electric-lighting interests. In meeting these conditions, for which it is so well adapted, the Nernst lamp has proven itself to be a trusty weapon in the hands of the central-station manager. It should not only win customers from the ranks of present gas users and prospective purchasers, but it should also prove useful, as a last resort, to prevent dissatisfied incandescent-lamp users from adopting gas illumination.

One of the chief advantages accruing to the central station through the use of a high-efficiency lamp is that it enables the company to maintain its rates under all conditions, and where the old flat-system of charging is still in vogue and it is desired to change over to the meter basis, the Nernst lamp becomes valuable as a means of doing so without causing rebellion among the current users.

It may be contended that high efficiency is a negative argument in so far as the central station is concerned, since it is in the market to sell current and a lamp that gives twice the useful light for the same energy consumption is, from that point of view, not a paying proposition. Fortunately for the electric-lighting business this opinion is held by a rapidly increasing minority, and it is now widely recognized that the business of the lighting company is to sell good light. Hence the past endeavors on the part of lighting interests to supply the existing need of a more efficient incandescent lamp—one that would enable them to get business of all classes. This end has virtually been attained in the Nernst lamp, with the additional advantages of high voltage and better sized units.

Another point that demands the attention of the lighting company whose circuits are loaded to their full capacity is that it is less expensive to provide for increased business by the introduction of high-efficiency lamps, costing about $35 per kilowatt, than it would be to install additional station equipment at $150 per kilowatt. With a 220-volt lamp, a material saving in line loss is also to be included in such a comparative estimate.

It is now generally conceded that the Nernst lamp holds a distinct advantage on account of the color or quality of its light. It is wholly due to this feature that the lamp has created for itself a special field in art gallery illumination. After a series of careful tests to determine which of the modern illuminants was most effective in bringing out the true colors of the paintings and providing the most pleasing general effect, the Nernst lamp was selected to illuminate the interior of the Art Buildings at the late St. Louis Exposition. It may be noted here that the 1500 three-glower lamps used here were supplied with 25-cycle current. Similar tests were made, and the lamp was extensively adopted in the new Albright galleries of Buffalo. This latter installation, which is also operated on 25 cycles, is unique in the respect that the lamps are located between the inner and outer skylights and the light is projected through the skylight, giving a most natural and pleasing illumination without visible sources of light.

Naturally, this advantage in color, combined with those of steadiness, economy and neat appearance, would also tend to make the Nernst lamp especially adapted to store-lighting, and,

as a matter of fact, experience in the past indicates that this is, and will continue to be, its most popular field. Department and other large store managers have come to a realization of the possibilities of the new light, and several installations of this kind, which usually come under the domain of private-plant service, have recently been won over to central-station service with the Nernst lamp.

Assuming that the above-mentioned and well-known advantages will be self-suggestive of the many applications of the lamp to the various other classes of commercial lighting, we will not try to incorporate a detailed discussion of this nature within the limits of our paper. Numerous large installations of an isolated character throughout the country stand in evidence of the lamp's usefulness in bank, office, mill and factory lighting.

Several street-lighting systems in satisfactory operation also testify to the fact that the field of the Nernst lamp is not confined to indoor service alone. While a system of the six-glower type compares very favorably in the results obtained, as well as in cost of generating equipment and maintenance, with the modern alternating or direct-current series arc system, the single-glower unit, in competition with gas burners, for the lighting of small towns and suburban districts of the larger cities, promises to become a more aggressive factor in outdoor service.

DISCUSSION

Mr. W. J. Hazard (Golden, Colo.): I ask what is the prospect for supplying lamps for direct current?

Mr. Roberts: I would say that we recently conducted a number of tests on direct-current lamps which showed very favorable results. As a result, we have made arrangements to distribute a number of these lamps so that commercial tests may be made upon them in different central stations.

Mr. Williams: I would suggest that this is a subject upon which we should have the fullest discussion—the extent to which the Nernst lamps have been used by central-station managers and the results of their use. Mr. Dunham, for example, has had a great deal of experience with these lamps in Hartford. We have a small territory in New York in which we have 105 or 110 kilowatts. We find that the lamp does not materially interfere in the field of either incandescent lighting or arc lighting.

but fills a gap between the two; a gap that would be filled, perchance, if we had a 200-cp incandescent lamp. The light is of high quality, and wherever it has been used it has seemed to give entire satisfaction. We find, however, that the field admits of the largest development with the three and six-glower lamps rather than with the single-glower lamp, which competes more directly with the ordinary incandescent lamp of 16 candles. The life is fairly satisfactory, and the cost of renewal is slightly over one cent per kilowatt-hour and probably would not reach one cent per kilowatt-hour were the lamps used to a larger extent. The growth, while rapid in one sense, is slow in another. The income is substantially $11 annually per 88-watt glower, which is about twice the average equivalent income of an incandescent lamp of 16 candle-power. Through the medium of the Nernst lamp we have secured the return of a large amount of business—large relatively for this small territory—that had left us and gone to the intensified gas burners. We feel that, while we have had some experience covering more than a year with the Nernst lamps, we should like to get the benefit of the experience of the other companies with these lamps.

MR. W. E. RUSSELL (Massillon, Ohio): I ask Mr. Roberts what is meant by the statement on page 274, where he says: "Several street-lighting systems in satisfactory operation testify to the fact that the field of the Nernst lamp is not confined to indoor service alone." I ask him to name some of the towns that have Nernst lamps for outdoor lighting.

MR. DUNHAM: I have used the Nernst lamp for over three years—almost four years. We have 3500 glowers—about half as many as they have in Pittsburg, although our population is not quite half the population of Pittsburg, being 90,000. The lamp has filled a place, and we do not see how we could possibly get along without it. As a displacer of gas-arcs it is remarkable. If you put up a three-glower Nernst lamp in a place where they have had a gas-arc, the gas-arc immediately comes out and there is no question about it. I think that has led to the use of the lamp in our city very largely.

In answer to the question of Mr. Russell, I would say that we have one suburban town within four miles of Hartford in which we have placed 248 lamps in the streets, all single-glower lamps, and they have given great satisfaction. They started

with about 140 and they have added to them every year until now they have 248. They have been running about three years—that is, the original installation. We charge $18 for all-night service, and we find it is very good business. They take the place of the ordinary gas light used in such towns.

I think the only thing that has retarded the progress of the Nernst lamp is the fact that the high price of the glower has led the users of the lamp to try to get the full life out of the glower. We have tested the life of the glower—the present glower is a very good one and the whole lamp has been greatly improved in the last year and a half—and we find that the life of the glower is now from 800 to 840 hours; if you put up ten lamps they will average about 840 hours. We have one lamp now running that has been running for 1700 hours. But if you undertake to get the full life of the glower you are almost sure to burn out the heater, because if the glower is burned out in the night, when it may not be noticed, the current goes on and burns out the heater. The heater is a very expensive affair; the list price is 75 cents. Three-fourths of our entire output in Hartford is in single-glower lamps. They find uses in all kinds of places. We put them out on a card system and do not let any lamp burn more than 450 hours. Like all lamps, the candle-power of the Nernst lamp, if it is a 50-cp-glower lamp, will burn for the first 50 hours at 72 candle-power; it then drops to 62 and stays there for about 450 hours, so you are giving not a 50-cp lamp, but a 60-cp lamp. When it begins to drop below that it drops much more rapidly. Our system is to give the best light we can, and we take the lamps out and trim them when they reach a limit of 450 hours; but all stations can not face such a proposition as that. If the glowers in this country were sold at what you might call a fair commercial price, everybody would use them. On the other side, the glower sells for 2.25 cents, and in addition to that they give something besides. Here, the glower runs from 17 to 20 cents. Of course that price was made because originally there were great expenses involved in developing this glower. Those expenses have to a certain extent been compensated for, and when the Nernst lamp people get ready to put the price of the glower down to eight cents they will increase their sales very materially.

Mr. Roberts: In further reply to Mr. Russell's inquiry in

regard to street lighting, I have made a list from memory of some of the cities in which the Nernst lamp is used for street lighting. This list includes Unionville, Conn.; Sewickley, Pa.; Burlingame, Kan.; Berwyn, Ill.; Goldfield, Nev.; Tonopah, Nev.; Golden, Colo.; Deming, N. M., and Coalinga, Cal.

Referring to the statement in my paper as to the extent of the Pittsburg maintenance bureau, I would say that the 7000 glower units mentioned do not include many large isolated installations in Pittsburg where the maintenance is conducted in a private manner, nor a large number of lamps that are maintained by the local lighting companies.

(The meeting then adjourned until eight o'clock in the evening.)

FOURTH SESSION

President Davis called the meeting to order at eight o'clock and announced the first business to be the paper entitled *Some Investigations of Inductive Losses*, by Mr. E. P. Dillon, of Colorado Springs.

Mr. Dillon presented the following paper:

SOME INVESTIGATIONS OF INDUCTIVE LOSSES

In presenting this paper it is not the claim of the author to set forth any new facts or discoveries, but rather to emphasize some of the points in connection with operating central stations under adverse inductive conditions. The losses attendant on such operation are, no doubt, well known to engineers and managers, but unless the matter has been investigated the importance of the subject is liable to be slighted.

The plant having a purely lighting load is comparatively exempt from these troubles, but when the power business, supplied by alternating-current motors, begins to grow, then the complex conditions, due to inductive effects and other alternating-current phenomena, become important and are due some consideration.

It is a well-known fact that an induction motor, despite its many excellent qualities, has a low power factor at low loads. The power factor is maximum at approximately full load, dropping both above and below full load, the drop being very rapid below half load.

It is a noticeable fact that a great many power consumers have a little knowledge, which is just enough to be dangerous. Rather than confer with the power company, whose business it is to show what will best serve its customers, the prospective power user consults his own vast storehouse of wisdom to determine the size of motor necessary to do his work. Then, with an eye to future development in equipment, occasionally influenced by a not too conscientious salesman, he proceeds to buy a motor sufficiently large to handle his work for several years to come. The result is that he has a motor that will never be loaded more than 50 or 75 per cent, and suffers a loss of efficiency in his motor, besides loading up the transformers and other apparatus with wattless current. The result of a number of these cases to the central-station company is that its system is loaded up with motors not adapted to their load, and, in consequence, it has a system with low power factor, which increases the cost of operating without increasing the revenue.

Let us now see what losses these conditions bring about. We will consider primarily the line losses. As a matter of convenience for computing lines for alternating current, the following power factors have been generally accepted:

Incandescent lighting and synchronous motors, 95 per cent
Incandescent lighting and induction motors, 85 per cent
Induction motors alone, 80 per cent

But in many instances an induction-motor load will not give an 80 per cent power factor, and it is not unusual for an induction motor and lighting load to give less than an 85 per cent power factor, especially where the motor load is large compared with the lighting load.

In lines of moderate length where the inductance is large compared with the capacity the losses in transmission are energy loss and drop in voltage, due to energy loss, inductance and power factor. The energy loss is the C^2R loss in the line, and for a given delivered voltage C will vary inversely as the power factor, C being the current in the line. Therefore the energy loss varies inversely as the square of the power factor. The line drop in voltage will depend not only on the power factor, but on the frequency, size of wire and the distance between wires.

For convenience of illustration we will consider a concrete case: Suppose a case where 2500 kilowatts are to be delivered a distance of ten miles at 10,000 volts, 3-phase, 60 cycles, assuming a load factor of 50 per cent and a manufacturing cost of one cent per kilowatt-hour. The line is a two-circuit construction, each circuit having three wires of No. 0 B. & S. gauge copper.

Power Factor	Maximum Kw Loss	Per Cent Kw Loss	Loss in Dollars per Month	Per Cent E.M.F. Drop	Volts at Generator
1.00	165	6.6	594.00	7.0	10,700
.95	184	7.3	662.00	9.5	10,950
.90	204	8.1	734.00	10.5	11,050
.85	229	9.2	824.00	11.7	11,170
.80	258	10.3	930.00	12.4	11,240
.75	294	11.7	1,060.00	13.5	11,350
.70	337	13.5	1,214.00	14.4	11,440
.65	392	15.6	1,408.00	15.7	11,570
.60	458	18.3	1,650.00	17.0	11,700
.55	545	21.8	1,960.00	18.4	11,840
.50	660	26.4	2,375.00	20.0	12,000
.40	1,030	41.0	3,720.00	24.0	12,400

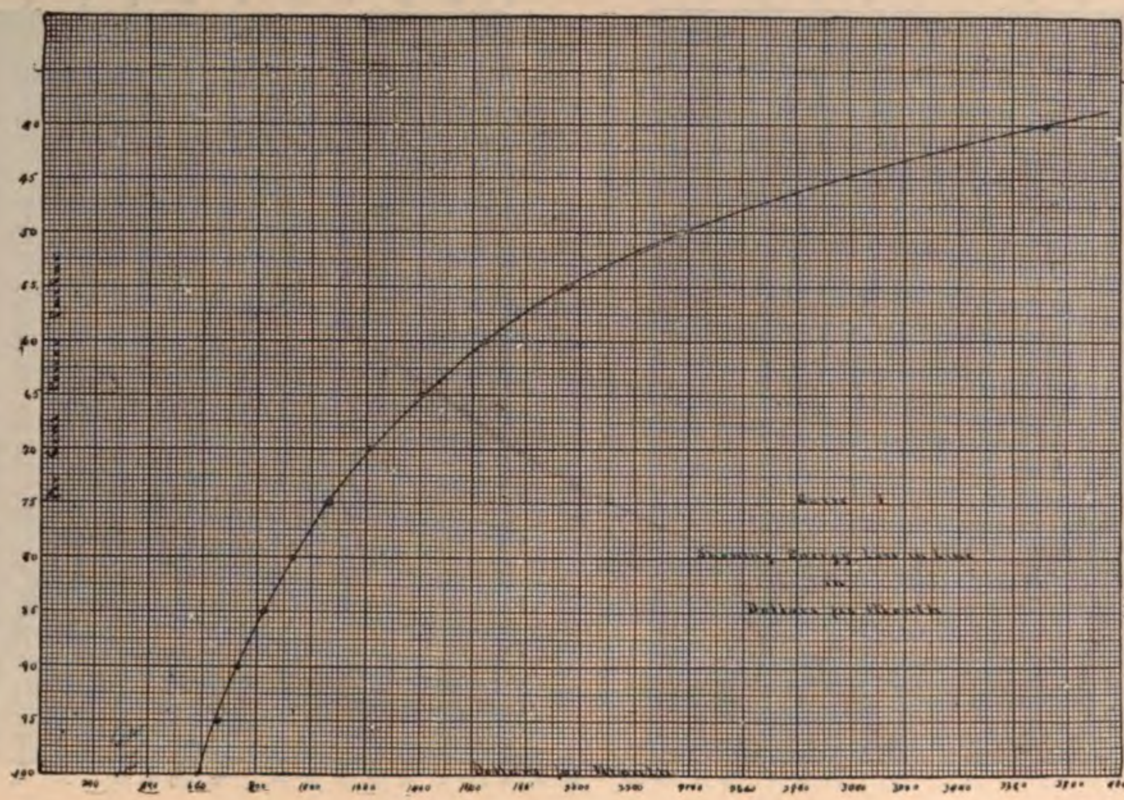


FIG. 1—ENERGY LOSS IN LINE IN DOLLARS PER MONTH

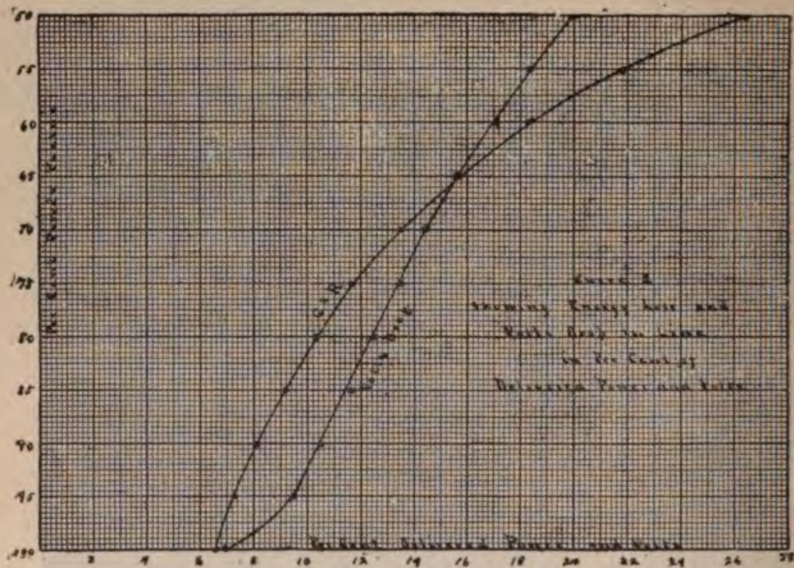


FIG. 2—ENERGY LOSS AND VOLTS DROP IN LINE IN PER CENT OF DELIVERED POWER AND VOLTS

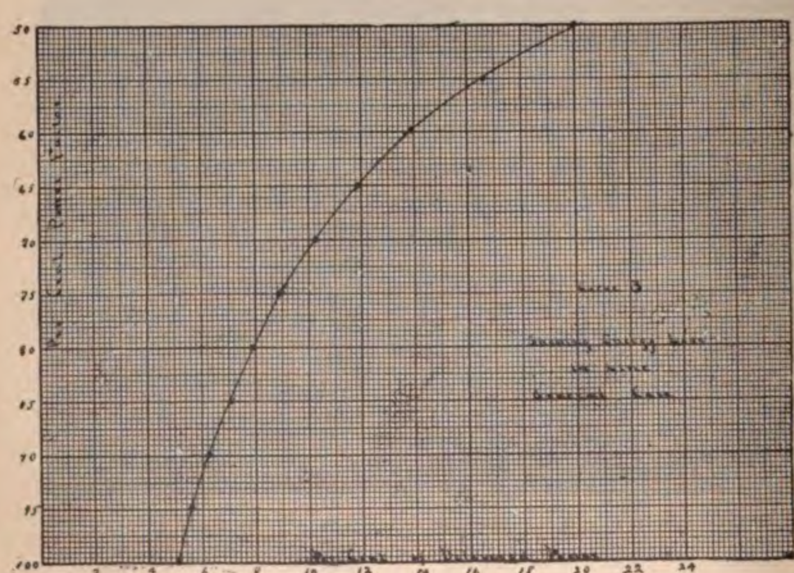


FIG. 3—ENERGY LOSS IN LINE—GENERAL CASE

An examination of the table will show that the energy loss in per cent runs from 6.6 per cent at 100 per cent power factor to 41 per cent at 40 per cent power factor.

The load factor is the ratio of the maximum to the average.

The loss in dollars per month is computed from the loss at average load at one cent per kilowatt-hour. A little study of the loss per month will show how rapidly the monetary losses increase as the power factor decreases. Another thing noticeable is the rapidly increasing loss in voltage.

Knowing the losses due to low power factor, let us consider some of the methods available to overcome the losses. In the first place where the power factor is very low it is probably due to motors working on light loads. This can be improved by a careful survey of the consumer's requirements and a rearrangement of the motors, with a benefit both to the consumer and to the company. Synchronous motors also, properly handled, will improve the power factor. Under this same head comes rotary converters. A case is possible where a synchronous motor running idle as a rotary condenser is a good investment. This should probably be located at the centre of distribution.

The corrective range of a rotary condenser depends upon its field capacity and armature ampere capacity. It is a well-known fact that a synchronous motor will have a leading current with an over-excited field and lagging current with an under-excited field. This is shown in curve 4.

In special case above, with power factor 90 per cent, let us see what size of rotary condenser will be needed to correct the power factor to unity:

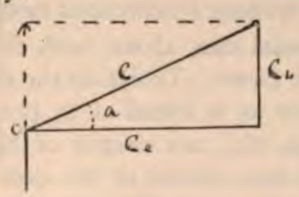


FIG. 4

At 90 per cent power factor the current in each leg $= C = \frac{W}{E\sqrt{3}\ \mathrm{Cos}\ a} = \frac{W}{E\sqrt{3}\,90} = 161$ amperes. Cos $a = .90$

$a = 25^\circ\ 50'$

This value of C is made up of two components, one in phase with e.m.f. $= C_e$, the other at right angles to e.m.f. $= C_l$, $C_l = C \text{ Sin } a = 161 \times .4357 = 70$ amperes.

The rotary condenser must have an ampere capacity of 70 amperes at 10,000 volts, or a k.v.a. capacity of 1211 kilowatts; *i. e.*, the rotary must operate with a leading current of 70 amperes in opposition to the 70-ampere wattless component of the system. This is a theoretical case of a motor without friction. In practice the motor will require some current as energy component to make up the losses and overcome friction. This feature will reduce to some extent the corrective capacity of the motor.

At 85	per cent	power factor,	theoretical	corrective	k v.a.	capacity	= 1550	kw.
" 80	"	"	"	"	"	"	= 1880	"
" 75	"	"	"	"	"	"	= 2200	"
" 70	"	"	"	"	"	"	= 2500	"

It is thus seen that at 70 per cent power factor the k.v.a. corrective capacity equals the delivered power, since the angle of lag is 45° and the energy and inductive components are equal.

Below 70 per cent power factor it is easy to see that the corrective k.v.a. capacity necessary would be greater than the amount of kilowatts delivered.

Let us now see what economy arises from the installation of a rotary condenser. Mr. Berg has shown that the efficiency of transmission increases with synchronous condensers up to about 95 per cent power factor. Beyond this the best conditions are obtained by running without synchronous motors.

Consider the special case above, with the system operating at 75 per cent power factor. To obtain the same C^2R loss at 75 per cent power factor as is found at 95 per cent power factor on line in above case, *viz.*, two circuits of No. 0 copper, it will be necessary to have two circuits of No. 000 copper. Owing to use of larger wire with same C^2R loss the drop in voltage is greater, being 9.5 per cent at 95 per cent power factor on smaller line and 11 per cent at 75 per cent power factor over the larger line.

The copper investment to secure the same energy loss in above cases, allowing 20 cents per pound for copper, follows:

Seventy-five per cent power factor, two circuits, No. 000, Investment	=	$32,983.20
Ninety-five per cent power factor, two circuits, No. 0, Investment	=	20,736.00
Saving of investment in favor of 95 per cent power factor	=	$12,247.20
Energy loss per annum at 75 per cent power factor	=	$12,720.00
Energy loss per annum at 95 per cent power factor	=	7,944.00
Energy loss saving in favor of 95 per cent power factor	=	$4,776.00

This saving in energy loss per annum represents 12 per cent on an investment of $39,800, allowing six per cent each for interest and depreciation.

This loss of energy between 75 and 95 per cent power factor can be overcome by the installation of the proper-sized rotary condenser to run idle on the system, with no load except friction and its internal losses.

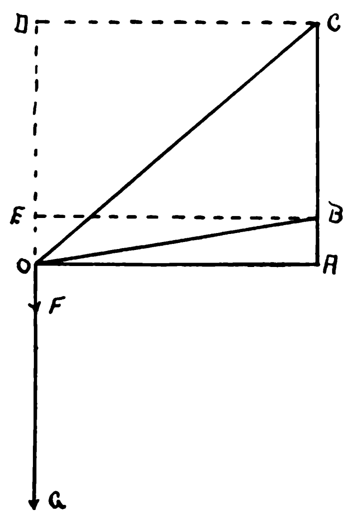


FIG. 5

At 95 per cent power factor, angle $AOB = 18° \; 11'$

Current $= OB = 152$ amperes.

$AB = OF = 152 \times \text{Sin } 18° \; 11' = 152 \times .312 = 47.5$ amperes.

At 75 per cent power factor, angle $AOC = 41° \ 24'$

Current $OC = 192.5$ amperes.

$AC = OG = 192.5 \times \text{Sin } 41° \ 24' = 192.5 \times .6613 = 127$ amperes.

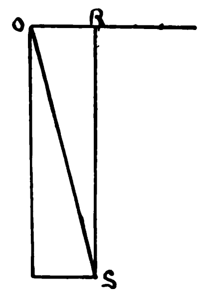


FIG. 6

To correct power factor to 95 per cent, it will be necessary to have a rotary condenser with current capacity equal $OG - OF = 79.5$ amperes. This gives a k.v.a. capacity of 1375 kw. Owing to the rotary having friction, *et cætera*, it will not give this correction. Assuming that the losses are 10 per cent in Figure 3,

$OS =$ k.v.a. of rotary $= 1375$ kw

$OR =$ energy component $= 137.5$ kw

$RS =$ corrective component $= \sqrt{1375^2 - 137.5^2} = 1370$ k.v.a.

This same method will apply to a synchronous motor partially loaded in determining the correction it will give. To obtain correction from synchronous motors, they should be used only on constant load, as the power factor changes with the load. The cost of installation of a 1375-kw rotary condenser, complete, should not exceed $14,000. This gives an excess cost of the condenser over additional copper of $1753.

The rotary, however, not only effects the same saving in energy line loss as additional copper in line, but it relieves the generator of working at excess voltage and acts as a regulator at the centre of distribution, even boosting voltage at its terminals. It is also probable that any system which would find itself in need of a rotary condenser, as outlined, would be in operation with certain lines constructed.

In order to install the additional copper requisite it would be necessary to expend considerable in labor and, possibly, extra pole line. This would quickly eat up the difference of $1753, first cost in favor of the copper, making the rotary condenser proposition the better.

Next, let us consider the case of a single unit, *viz.*, a 750-kw generator, 6600-volt, 3-phase, 60-cycle, normal full-load current rating at 66 amperes at 100 per cent power factor.

Power Factor	Percentage C^2R Loss	Amperes Generator	Kw at Generator
1.00	5.0	33	392
.95	5.5	34	395
.90	6.1	36	398
.85	6.9	38	401
.80	7.8	41	404
.75	8.9	44	408
.70	10.2	47	413
.65	11.8	50	419
.60	13.8	55	427
.55	16.5	60	437
.50	19.9	66	450

A glance shows that as the power factor decreases the generator becomes loaded up in current, while the engine continues to have less than its most efficient load. That is, at full-load current capacity of the generator the engine is not loaded much more than three-fifths. Consequently, the engine is running at low efficiency, which, in turn, affects the coal pile and runs up the cost per kilowatt-hour. A case that often happens is one in which one unit could carry the actual watts load, but, owing to low power factor, it becomes necessary to run more than one unit to take care of the excessive current demand on the generator, resulting in further loss in efficiency. Of course, there is an additional load on the engine, not shown in table, of C^2R loss in generator. This table shows how rapidly the plant capacity is consumed in useless output. Another objectionable feature is the drop in voltage, necessitating extreme voltage at generator to deliver sufficient pressure at the end of the line. The exciter demand also increases very rapidly.

Following are some data from an actual test:

The generators were two 750-kw, 3-phase, 6600-volt, 60-cycle generators, having a normal current rating of 66 amperes at 100

per cent power factor. These were supplying lighting and motor load. On secondary or lighting 'bus-bars was connected a 300-kw, 3-phase, 60-cycle, 2300-volt synchronous motor, having a normal current rating of 75 amperes at 100 per cent power factor.

In the first case two generators were running and the motor was running at very light load, pulling a line shaft, which did not amount to more than 50 horse-power. The motor field was varied and voltage at generator kept constant.

The following table shows variation of amperes in motor armature for amperes field, and also shows the boosting effect of the motor when over-excited, and *vice versa*. The normal voltage at motor was about 2320 volts.

Amperes Field	Amperes Armature	Volts at Motor
20	73	2270
25	51	2300
30	28	2300
35	15	2330
40	10	2340
45	16	2350
50	35	2350
55	47	2380
60	63	2390
65	75	2390
70	93	2420

In the second case the motor was partially loaded, pulling some 500-volt direct-current power machines. One generator was supplying the synchronous motor and a mill load of induction motors. Two tests were made, one in morning at high power factor, one in afternoon at low power factor. The load in each case was about the same, being, if anything, lighter in afternoon. The power factor was varied by the synchronous motor. Test shows as follows:

Power Factor	Volts Generator	Amperes Generator	Kw Field Generator	Volts at Motor
A. M., 95 per cent...	111.6	57.5	14.0	103.5
P. M., 70 per cent...	109.8	83.0	23.6	97.4

The volts at motor were reduced to the same value as volts at generator, being volts registered on voltmeter. This table

shows loss in voltage at receiving end, due to low power factor, the line drop being 7.2 per cent of generator voltage at 95 per cent power factor and 13.7 per cent at 70 per cent power factor.

The excessive demand on exciter at low power factor is also shown, as well as overloading of the current capacity of the generator.

The regulation of a generator, which is guaranteed within a certain per cent at unity power factor, drops very rapidly at

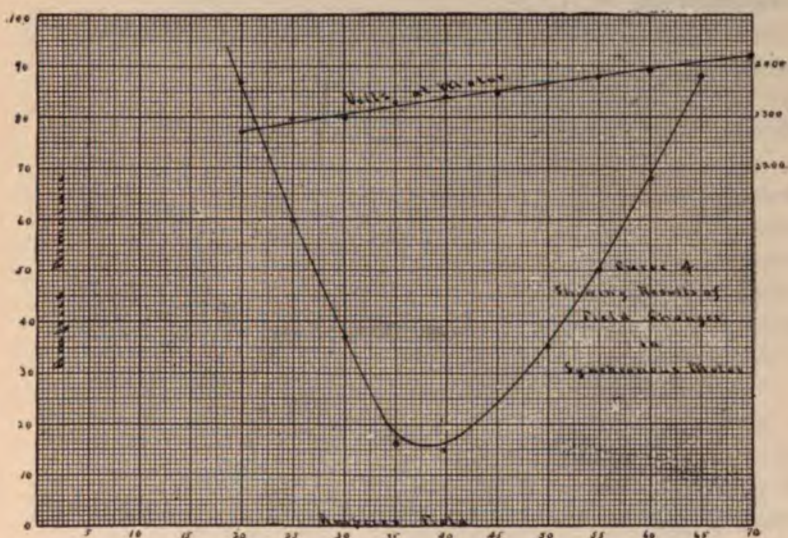


FIG. 7—RESULTS OF FIELD CHANGES IN SYNCHRONOUS MOTOR

lower power factors, and a low-power-factor load is very liable to be a fluctuating load. Therefore poor regulation is to be expected. Each case is a special problem and requires investigation of its peculiar characteristics.

The field for power is opening up rapidly, as the uses to which electric power can be put increase daily. With this tendency on the part of plants to develop power business, the question of transmission becomes an important one, and I trust that the facts presented here may emphasize the possible losses resulting from power supply and show the importance of co-operation with the prospective consumer in placing suitable motors. In some cases

companies might find it advantageous to offer some premium to their consumers for the maintenance of a high power factor, or embody a clause in contracts specifying that motors be installed whose rated capacities shall be within a certain percentage of their individual loads.

THE PRESIDENT: Is there any discussion on the paper that Mr. Dillon has read? If not, we will take up the paper on *The Choice of an Insulated Cable,* by Mr. Wallace S. Clark, of Schenectady, N. Y.

Mr. Clark read the paper, as follows:

THE CHOICE OF AN INSULATED CABLE

Every plant generating electric current uses insulated cables —in many cases only for station wiring; in others for its entire distributing system. The company that buys twenty-five or more miles of cable each year can and does devote a liberal allowance of engineering skill to the selection of the best and most economical types. There are a very large number of plants of moderate size that, with the growth of their business and the increasing tendency to substitute underground for overhead construction, are compelled to increase continually their investment in this line. Some of the points covered in this paper will, I hope, be of value to those responsible for the success of such plants.

The size of the conductor is determined by well-known methods, therefore it is only necessary to emphasize some points usually overlooked. There are two distinct conditions of service. One where the amount of current is not subject to any probable increase, such as instrument, generator and transformer leads; the second comprising all lines outside of the station that may be subjected to increasing loads due to the growth of business.

For the first class ampere (current-carrying) capacity, or mechanical strength in the case of small apparatus, is the determining factor. The current-carrying capacities given in the National Electric Code for rubber insulation are a fairly safe guide and the current densities given should not be exceeded.

For the second class of conductors, the cost of power at the switchboard, the load factor of the line, the limits of loss in transmission for satisfactory regulation of potential and operation of consuming device, the heating of the cable inshort lines, the probable increase in load with time and the interest charge on the cable investment are the principal factors in settling the size of conductor to be used. The Thomson law, so-called—that the most economical arrangement is where the cost of the power wasted and the interest charge on the table investment is a minimum—is the basis of many formulæ elaborated in different books.

Having determined the size of conductor required on theoretical grounds, consideration should be given one or two very practical points. First, do not use for underground construction

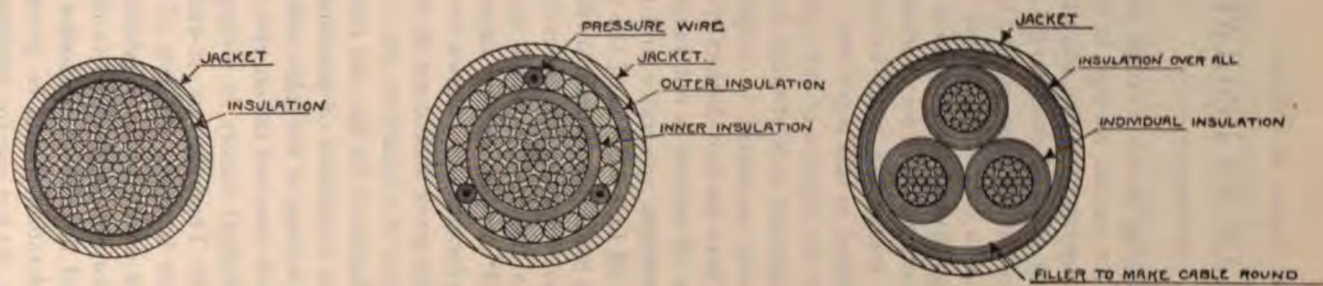


FIG. 1—THREE CABLE SECTIONS

cables so small as to be mechanically weak. I have in mind a station with a 6600-volt distribution where the cables ran from three-conductor 0000 to three-conductor No. 6 in size; the No. 6 constituting the smallest part of the installation and giving more trouble than the entire remainder of the system.

Second, if you use a duct system, keep in mind the fact that the cost of duct per foot is independent of the size of the cable in the duct, and select the size of conductors so that the cables will utilize a reasonable proportion of the duct area. Two No. 8 arc-light cables, single-conductor, in a three-inch duct, costing from 20 cents to 40 cents per duct foot, is evidently uneconomical. The standard three-inch duct will take cables of the following sizes, insulated for different voltages: Any voltage under 1500, single-conductor cables up to 2,000,000 circular mils; concentric two-conductor cables up to 1,000,000 circular mils; three-conductor cables up to 500,000 circular mils.

For 3000 volts, single conductors up to 1,500,000 circular mils; concentric up to 750,000 circular mils; three-conductor up to 400,000 circular mils.

For 6600-volt lines, which are practically all three-phase, the limit is found at three-conductor, 250,000-cm cable; 12,000-volt lines, the limit is found at three-conductor No. 0000 cable; on 24,000-volt lines at about 100,000-cm cable. It is assumed, of course, that the three-conductor cables are run on delta-connected circuits, and have the same wall of insulation between conductors and ground as between the conductors themselves. If the three-phase circuit is run Y-connected with neutral grounded, then the outer jacket of the three-phase cable can be made considerably less in thickness and larger cables be installed in the standard three-inch duct.

Figure 2 gives some curves showing the variation in cost per 1000 circular mils of copper contained in the cable for different sizes of cables and different working e.m.f. It will be noted that the lack of economy in the use of small conductors is most marked in the 15,000-volt class, where changing the size from No 8 to No. 6 wire increases the cost less than four per cent, while the conductivity is increased 58 per cent. Or, taking the larger sizes and going from No. 1 to No. 0, the cost is increased eight per cent and the conductivity 26 per cent.

These figures and curves are based on varnished cambric

cable, as this type of insulation is roughly midway in price between good rubber cable and good paper cable. With paper insulation the comparison would be less favorable to the larger conductors, while with rubber insulation the use of the larger conductors would show much greater economy.

There is another point especially noticeable in the use of potentials above 5000 volts, and that is that the safe working pressure for a given thickness of insulation is less in the very small

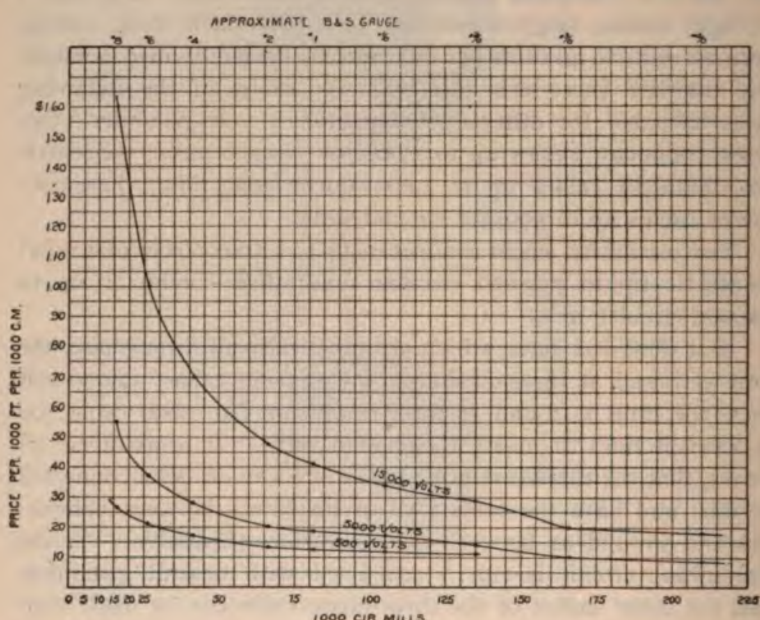


FIG. 2—VARIATION IN COST PER 1000 CM OF COPPER FOR DIFFERENT SIZES OF CABLES AND DIFFERENT E. M. F.

sizes of conductor. Or, to put this in another way, where the thickness of insulation exceeds twice the diameter of the copper core in high-potential cables with homogeneous insulation, we are not able to get the full advantage of the insulating wall, since the fall in potential, or potential gradient, is undoubtedly higher in the layer of insulation immediately adjoining the copper than it is half way between the copper and the outside of the cable; this concentration of pressure tending to break down first the inner layers of the insulation and finally puncturing the entire insulating wall. In

short, it is easier to make a 500,000-cm cable for 10,000 volts working pressure than to insulate a No. 14 wire for the same purpose.

The next point to be covered is whether single or multiple-conductor cables should be used. For station wiring single conductors in separate ducts, or runways, might safely be taken as the best modern practice. Maximum safety and reliability, and simplicity of arrangement, appear to have settled this question pretty definitely. For outside lines the service will largely decide. Direct-current railway feeders are normally single-conductor.

When ducts are high in cost and the load on one feeder is not heavy enough to require a cable utilizing most of the duct space, two feeders may be combined, as long as their course is parallel, in a concentric type of cable if it is desirable to preserve their identities to the switchboard. If it is not important to run the cables as separate feeders back to the switchboard, we may bunch two or more cables by means of a junction box into a single large cable which will run back to the generating plant; as, for instance, three 500,000-cm cables might be multiplied and a 1,500,000-cm cable run back to the station. This cable is readily installed in a standard three-inch duct, and there would be a saving in first cost of cable, a saving in duct investment and in switchboard.

For low-tension mains on the three-wire system, either three single-conductor cables or one three-conductor cable can be used. The three-conductor cable is slightly cheaper in first cost but not nearly as convenient for making taps to customers. Theoretically, with alternating currents there is a slight advantage in the use of the three-conductor cable. For low-tension feeders, which usually exceed 250,000 circular mils, in size, the concentric type of cable should be used for maximum duct economy. Smaller than 250,000-cm cables may be run as a flat twin conductor, and this type of conductor is always advisable for alternating current feeders with manhole transformers. It should be noted here that it is a modern practice, and one to be commended, in running a three-wire system to ground the neutral and run the feeders simply as two-wire feeders, providing a tree or trunk neutral to which the different points of distribution are connected and which runs back by means of a very heavy cable to the station.

The common practice in arc circuits is to use single-conductor cable. Where a number of circuits are in parallel for any distance

an excellent plan is to combine them into a multiple-conductor cable. This saves in first cost, in cost of installation, and in cost of ducts. If a number of small leaded cables are run in one duct, which is necessary in order to keep the duct investment reasonable for the arc circuits, one cable burning out in a duct is very likely to injure the others. Further, the cables are liable to mutual injury when being installed, and it is quite difficult to draw out one cable without damaging the others. These are defects that may be avoided if a multiple-conductor cable is used.

Single-phase two-wire lines not exceeding No. 0000 size should be run as twin conductors unless numerous taps are made, in which case the greater convenience in making joints may justify the use of the single-conductor cable. The concentric type of cable for single-phase work is losing favor in England and on the Continent and has never been in favor in this country. The most serious objection is that in a large network of concentric cable on single-phase or three-phase alternating circuits, great care is required in switching, since the outer conductor has a very much higher electro-static capacity to earth than the inner conductor, giving rise to surging of the voltage and current and to burn-outs. For three-phase work, three-conductor cables, and for two-phase (quarter-phase) four-conductor cables are required, both on economic and engineering grounds.

Types of Insulating Material for Different Services: (a) *Station Wiring*—I believe the majority of engineers who have had experience in central-station construction now consider that cables without metallic sheaths are better than leaded or other metal-sheath cables for this class of work. The lead sheaths are generally grounded, and must be grounded in a high-tension system to prevent the accumulation of static charge. These grounded lead sheaths offer the arc from any conductor to earth in their neighborhood a ready inducement to spread and cause trouble on adjoining cables. The lead sheath on circuits exceeding 5000 volts, and on all voltages if the cable is paper or fibrous insulation, must terminate in an end bell or pothead to prevent the breakdown of the cable at the terminus of the lead sheath. This end bell in addition serves as a seal to prevent the absorption of moisture in the case of paper or similar cable.

Cables for tensions not exceeding 750 volts that can be run in dry non-metallic ducts without pockets where water may col-

lect, or on suitable incombustible insulators—porcelain, glass, slate shelves, concrete, etc.—require insulation only to prevent shocks to operatives and short-circuits due to mechanical causes, such as a workman dropping a wrench or bar across two bare conductors. An excellent type of cable for this work is one insulated with varnished cambric tapes and asbestos (asbestos being on the outside), finished with a flame-proof braid. Such a cable can be operated continuously at the boiling point of water without injury. The varnished cambric, being inclosed in asbestos, does not introduce any additional fire risk, as do weather-proof or rubber cables. The rate of deterioration is less than with other types and the cost low. The first use of this type on a large scale was in the Harrison street station of the Chicago Edison Company in 1893. Since then they have been largely used in station practice and have never given any trouble; they have in one or two cases come through fires practically uninjured.

For pressures of 1000 volts and upward we must use rubber cables of good quality, or some satisfactory substitute. Such cables, unless protected by individual fireproof runways, should be protected on the outside by an asbestos jacket. This jacket will prevent fire following along the cable or bunch of cables; it also acts as a protection, to a considerable extent, from the destructive action of an arc from an adjoining conductor.

If rubber insulation is used it should be of good quality, and such cables cannot be cheaply made, owing to the present extremely high price of the better grades of crude material. Rubber cables should not be operated at temperatures exceeding 125 degrees Fahrenheit if reasonable long life is expected of the insulation. Lower operating temperatures are most desirable, as they will do much to prolong the life of the insulating wall. Higher temperatures cause very rapid deterioration of the insulation. In England, and to a less extent on the Continent, various patented compounds, made usually from oils and bitumens, have been tried, and with fair success, on low-tension work, and where they are not subjected to any high degree of heat. These cables are not adapted to the high temperatures that prevail during summer in most stations, nor will they give satisfaction when run at the high-current densities common in this country. The best that can be said of these insulations is they are more or less successful imitations of vulcanized rubber and generally have all the faults of rubber insulation more or less exaggerated.

You are all no doubt familiar with the large use of oil varnish films in the insulation of electrical apparatus such as transformers, generators, motors, etc., usually used in combination with some woven fabric to give mechanical support to the film. Six years ago, after extended experience with this type of insulation, the company with which I am connected became convinced of the value of the insulation for cable work, especially on cables of large size or for very high voltages. The insulation developed consists briefly of cloth tapes especially treated and coated on both sides with multiple films of varnish. These tapes are applied to the cable, and between the tapes is a thin film of plastic insulating material which does not dry or become hard. The function of this plastic layer is to increase the flexibility of the cable by allowing the tapes to slide one upon another when the cable is bent. Cables thus insulated are tested and finished the same as rubber-insulated cables with braid, lead or any other desirable finish.

This type of insulation has all the good qualities of paper cables. It will withstand as high temperatures; it is more flexible; has a considerably higher dielectric strength; and finally, most important of all, does not absorb moisture and can be used in interior work without a lead jacket. The varnish and cambric insulation, which we will speak of as V. C. for the sake of brevity, will not decentralize or deteriorate under temperatures destructive to rubber insulation. Mineral oil will not rot it. So far as data are obtainable, its rate of deterioration is less than that of vulcanized rubber of the best quality under like conditions. Its dielectric strength is fully equal to that of rubber insulation. The method of manufacture is one insuring a homogeneous insulation of uniform dielectric strength—a point extremely difficult of attainment in rubber-insulated cables for high voltages. This type of insulation, I believe, is especially suitable for station wiring in the higher potentials and larger sizes of cables. It lacks only one quality to make it approach very closely the ideal—it is not in itself fireproof; neither is rubber, nor paper. Like rubber-insulated conductors, it may be flame-proofed with asbestos on the outside, or, in fact, with any available material that can be used over the other insulations. It has not as yet been applied to very small conductors for potentials below 1000 volts; for these rubber is at present the best available insulation. For small conductors for high tension an inner wall of rubber and an outer

wall of varnished cambric makes an extremely effective cable and one much cheaper than cable built entirely of rubber.

Passing to conductors outside of the stations, these may be roughly divided into transmission lines, practically always operated at potentials of 4000 volts or more and running to sub-stations. The second class of cables comprises the distributing systems with feeders seldom exceeding 3000 volts and mains to which customers are directly connected operating at 500 volts or less. Circuits outside of the station using insulated cables are practically all underground. There are a few cases where high-tension leaded cables are run on pole lines supported by a steel cable similar to telephone practice, but this may be regarded as a temporary expedient.

Underground construction in this country consists almost entirely of lead-jacketed cables in conduits, the most permanent type of duct being thoroughly vitrified tile. For installations where electrolysis can be guarded against, or is not to be feared, paper-insulated lead cables give thoroughly satisfactory service when carefully installed. Where severe electrolysis is counted on or where the ducts are filled with water for considerable lengths of time varnished cambric or rubber leaded cables should be used to ensure against interruptions of service.

There are some successful installations of rubber cables, not lead-sheathed, in operation. It is, however, questionable if this is the best practice, since the ultimate life of the leaded cables will, I believe, be sufficiently extended to warrant the extra cost of the lead jacket.

Services to customers are installed in short lengths, although amounting to a considerable proportion of the cost of an underground system, and are most convenient when insulated with a material not requiring special sealing of the ends to protect against the absorption of moisture, and it is a common practice to use rubber-insulated cables for this purpose. We believe varnished cambric to be equally well suited to the requirements.

Where sub-aqueous lines are called for various constructions are possible. With narrow, shallow streams or canals the line of conduits may be dropped with deep manholes and the ducts carried underneath the bed of the stream. This usually necessitates draining the ducts toward one manhole and providing a small pump to keep the manhole clear of water seeping in. Wide

shallow streams can have a trench dredged or dug across them and cables with band steel armor laid in the trench which will usually be rapidly filled with silt. For deeper streams or wider streams armored submarine cable is required. A method used with success in some cases is to lay a cast-iron water main with specially bolted ball and socket joints along the bottom of the river and to draw an unarmored leaded cable through it. Tunnels can, of course, be used, but except for a very heavy line containing a number of cables this construction is extremely expensive, and it is cheaper to install one or more spare cables which can be switched into service in case of accident to one of the operating cables. It is perhaps well to mention here that where a submarine cable or underground cable is inserted in a pole line of any length adequate lightning protection should exist at each end of the cable.

There is one type of cable largely used in England, and almost universally in Continental Europe, of which we do not avail ourselves as much as we should for underground work. This is the so-called Band Iron Armored Cable. Leaded cable is wrapped with tarred jute over this, with two overlapping steel tapes, each from one-thirty-second to one-sixteenth inch thick. The outer tape covers the butt joint in the inner tape and is protected against corrosion on the outside by an additional jacket of compounded jute. Such cables buried directly in the earth have been giving first-class service in some cases for twenty years. They are in use for pressures from 250 up to 15,000 volts, and lines of even higher potentials have been installed, but for too short a time to be cited.

There are many cross streets where only a distributing main of, say, three 0000 conductors is required. A single duct with small manholes every 75 feet for service distribution will cost at least 50 cents per duct foot, including service manholes and omitting all paving charges. Single 0000 cables suitable for this use can be armored for approximately eight cents per foot, or 24 cents for three cables, showing a direct saving of 16 cents per foot of three-wire main, allowing 10 cents for trenching. If smaller sizes of conductor were used in the comparison the saving of the armored cable over the duct would be largely increased, since the duct charge is fixed, while the cost of armoring is approximately proportional to the size of the

cable. With such constructions services can be installed at any point, the joint being protected by cast-iron T boxes. Such cables are usually installed inside of the curb lines, saving the expense of disturbing expensive pavement. Cables thus installed can run into manholes belonging to the conduit system at either end of the block and be then worked in with the regular distributing system. For service to buildings set back from the street, for an underground system connecting a group of buildings of a permanent character such as a college with fine grounds, where overhead lines are an eyesore, and for complete systems in small cities where the conduit system is too expensive, this type of cable represents a neglected opportunity, I believe, to American engineers.

PROPER REQUIREMENTS AS TO TEST PRESSURES

Before it is shipped from the maker's factory every cable should be tested with an e.m.f. higher than the maximum working pressure. If possible, a similar test should be made after the cable is installed and jointed. As to the relation which these test pressures should bear to the working pressure, the duration of the tests, etc., there exists considerable diversity of opinion. For a good many years the writer has advocated two and one-half times the working pressure for thirty minutes to an hour as a factory test and twice the working pressure for the same length of time after the cable is installed. Cables tested under these requirements have given no indication in practice that the margin of safety was not ample. Some engineers, desiring a higher factor of safety on important and large installations, specify a factory test of three times the working pressure and a test installed of two and one-half times. Any requirement more severe than this represents a questionable investment on the part of the purchaser. It is especially undesirable to make very high potential tests for very short periods of time, since the cable may be decidedly weakened by such treatment, although it does withstand the high-potential test for the brief period specified. In short, the words "breakdown test" should not appear in cable specifications, in the writer's opinion. Boilers are tested to see if they are safe for a given working pressure, but such test is not usually referred to as a bursting test. Cable tests should be considered on the same basis. They are not to show the ultimate strength of

the cable, but to show that the cable is safe and satisfactory cable for the purpose for which it is intended.

It should, of course, be understood that the above refers to cables for 2000-volt circuits or over, since in lower voltages the necessary mechanical requirements frequently call for a wall of insulation sufficient for a 3000-volt test or even a 5000-volt test on cables which are to operate at 250 volts. A variation in tests called for by some engineers, which is a very good one, in my opinion, is to test the cable for one hour at two and one-half times the working pressure and at the end of that period to raise the pressure to three times the working pressure for one minute.

Paper cables are not generally tested at more than 2300 volts for each one-thirty-second of wall; rubber cables at 2500 volts for each one-thirty-second of wall; varnished-cambric cables we are enabled to test with 2800 volts for each one-thirty-second of wall. These figures apply, of course, to the ordinary commercial cables as made to-day. They can be exceeded on specially made cables of all types. The size of the cable has a considerable bearing on the pressure test, and the figures above represent the practice on cables running from No. 6 and larger, for working pressures from 2000 to 20,000 volts.

In concluding this paper I would strongly advise any central-station man who contemplates underground construction to procure a copy of Mr. Louis A. Ferguson's paper, read at St. Louis last year at the Electrical Congress, on underground construction, as it contains a mine of valuable information, which, so far as I know, has nowhere else been published.

It is to be regretted that more time and thought have not been given in the past to the selection of the proper types of cable for given uses, as the subject is one which, on account of both its commercial and engineering importance, deserves careful study.

THE PRESIDENT: Does any member wish to discuss the paper presented by Mr. Clark? If not, we will take up the next paper, *Mercury Arc Rectifiers*, by Mr. P. D. Wagoner, of Schenectady, N. Y.

MERCURY ARC RECTIFIERS

There has existed for some time a demand for a compact, efficient and low cost device for rectifying alternating current for various purposes, particularly for charging storage batteries. Many satisfactory auxiliary appliances for use with storage batteries have been developed from time to time, and a number of devices for charging batteries have been placed on the market. The best known devices for this purpose are the motor-generator set, the single-phase rotary converter, the synchronous or mechanically driven rectifier, and the chemical rectifier. A plant, consisting of a gas or gasolene engine, driving a direct-current generator, may also be included.

It is unnecessary for the purpose of this paper to describe any of the above devices in detail, but it may be of interest to mention some of the disadvantages that may be found in their use, which disadvantages have seriously retarded the more extended use of vehicles propelled by electricity. Such vehicles have many advantages over vehicles driven by other motive power. With some suitable provision made for battery charging that is simple, cheap, and operative by unskilled help, the use of the electric vehicle will be greatly popularized and the income of the central station increased.

The Motor-Generator Set

The motor-generator set has been somewhat high in first cost and has required large floor space for installation. The efficiency at full load of sets of proper size for charging vehicle batteries has been comparatively low, and at light load, very low.

Single-Phase Rotary Converter

The single-phase rotary converter is not as flexible as the motor-generator set, particularly as regards voltage, and it requires more care and higher intelligence in starting and operating.

Synchronous or Mechanically Driven Rectifier

This type of machine is comparatively small, but requires considerable attention, as the direct-current brushes are apt to

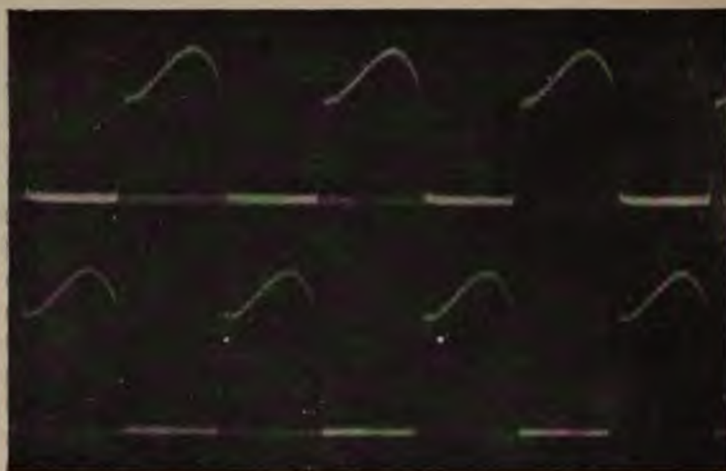


Fig. 1—Anode Currents, Showing Relations of Simultaneous Values in Anodes *A* and *A'*

Fig. 2—Direct-Current Wave Form with Its Accompanying Zero Line Shown in Its Relation to Impressed E.M.F. This Is a Combination of the Anode Current Waves in Fig. 1

to go out. In this connection, it is interesting to note that even when operating the rectifier on a 10,000-cycle source of supply, the same holds true. Such a wave form, even if obtainable, would be of no commercial value.

By means of suitable reactances, the current is held over the zero value and the pulsations are smoothed out, the current at the cathode becoming not only uni-directional, but a true direct current, with pulsations of small amplitude.

The resulting direct-current wave form is shown in Figure 2, which is the result of superimposing the two curves shown in Figure 1. The action of the reactance can be seen from Figure 1, by carefully observing that the wave shape is evidently no longer a sine wave, but that during its operation the reactance is sustaining the current at a higher value than it naturally would be; also, that the current curves in each anode overlap by an angle of overlap of approximately 20 degrees, thus eliminating the zero points previously mentioned.

The cathode is then one terminal of the direct-current circuit. The junction between two reactance coils, such as referred to above, connected between the anodes, furnishes the other terminal, so that at any instant, the circuit from the alternating-current line is composed of a rectifier arc, the load, and one of the reactance coils. The other coil is at the same time discharging the energy stored up during the previous half wave, at which time it was in the line circuit.

The initial ionization of the mercury vapor is accomplished by a small starting anode (see Figure 3), which is brought into contact with the cathode by a mercury bridge formed by a slight shake of the tube. The breaking of this mercury bridge starts a small initial arc, and the arc thus obtained excites the cathode, giving the necessary ionized vapor, which enables the working anodes to immediately become active and the tube to start.

A detailed idea of the operation of the mercury arc rectifier circuit may be obtained from Figure 3. Assume an instant when the terminal *H* of the supply transformer is positive, the anode *A* is then positive and the arc is free to flow between *A* and *B*, *B* being the mercury cathode. Following the direction of the arrows still further, the current passes through the load *J*, through the reactance coil *E* and back to the negative terminal on the transformer *G*. A little later, when the impressed e.m.f. falls below a value sufficient to maintain the arc against the counter

e.m.f. of the arc and load, the reactance E, which heretofore has been charging, now discharges, the discharge current being in the same direction as formerly. This serves to maintain the arc in the rectifier until the e.m.f. of the supply has passed through zero, reverses and builds up to such a value as to cause A' to have a sufficiently positive value to start an arc between it and the mer-

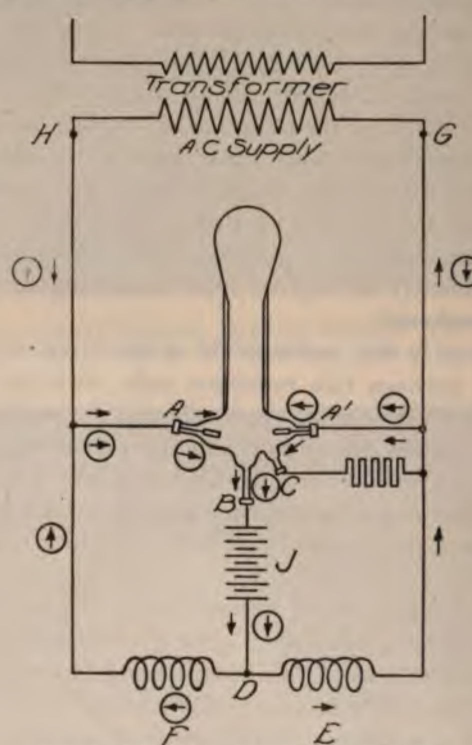


Fig. 3—Rectifier Connections Shown Diagrammatically

cury cathode B. The discharge circuit of the reactance coil E is now through the arc A' B, instead of through its former circuit. Consequently the arc A' B is now supplied with current, partly from the transformer and partly from the reactance coil E. The new circuit from the transformer is indicated by the arrows enclosed in circles.

The charge and discharge voltage of one reactance coil is clearly shown in Figure 4, and the voltage across the arc A B or A' B is shown in Figure 5. The measurement of the two halves

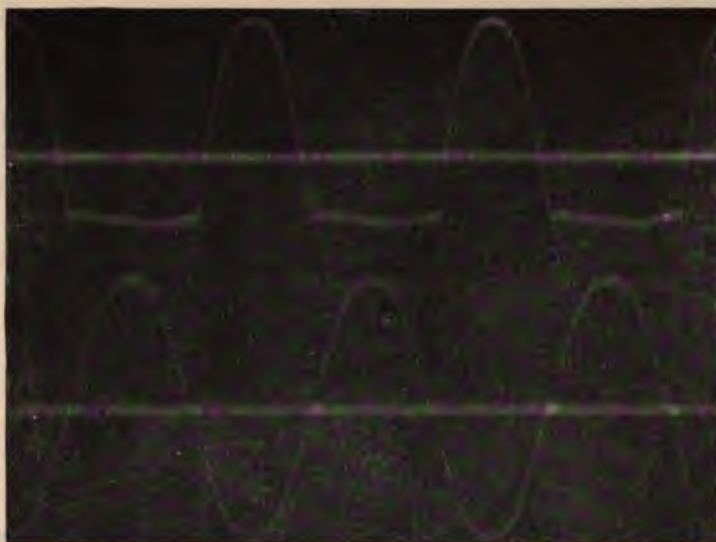


FIG. 4—CHARGE AND DISCHARGE VOLTAGES OF REACTANCE, SHOWING APPROXIMATELY CONSTANT DISCHARGE VALUE, IN ITS RELATION TO IMPRESSED E.M.F.

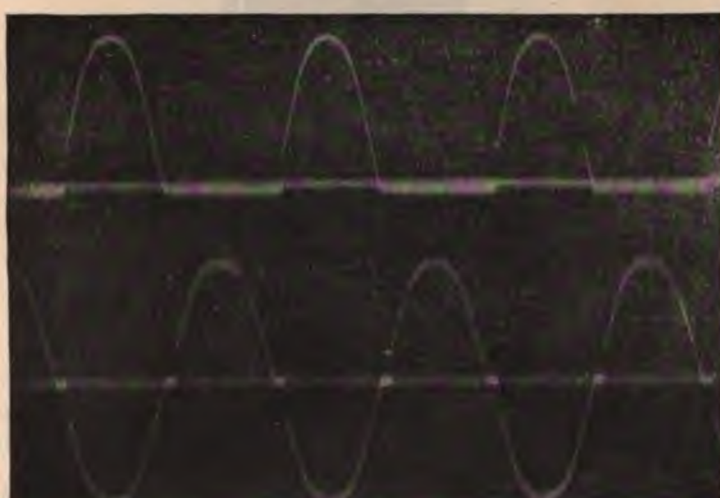


FIG. 5—VOLTAGE BETWEEN ANODE AND CATHODE, SHOWING CONSTANT DROP OF 14 VOLTS WHILE ARC EXISTS, IN ITS RELATION TO IMPRESSED E.M.F.

of the cycle shown in Figure 5 indicates the length of time the arc holds over the zero point. The amount of reactance inserted in the circuit when these curves were taken reduces the pulsations of the direct current sufficiently for all ordinary commercial purposes. Where it is advisable to still further reduce the amplitude of the pulsations, as, for instance, in telephone work, this is done with very slight reduction in efficiency by means of reactances.

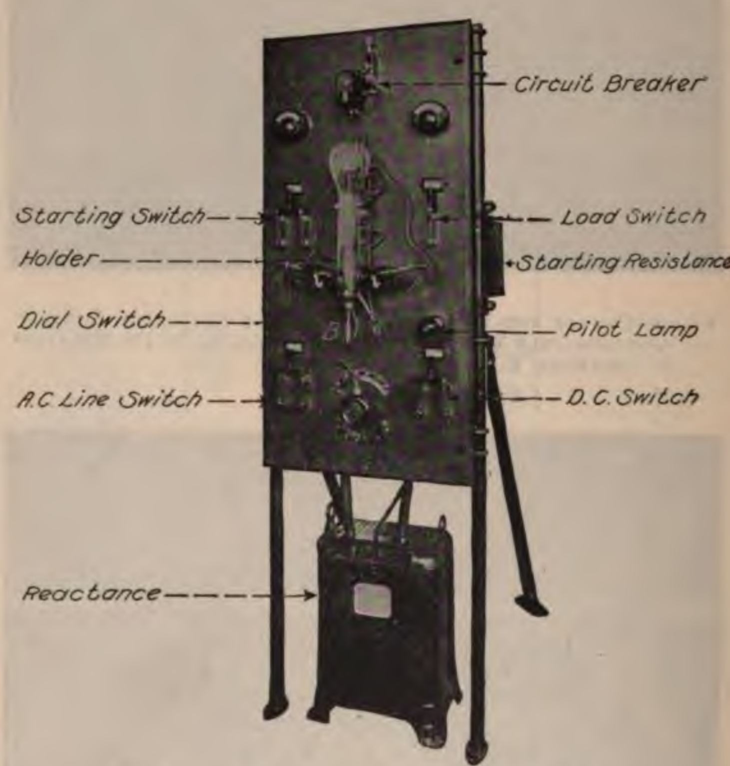


FIG. 6—MERCURY ARC RECTIFIER CHARGING PANEL

Detailed Description of Commercial Outfit

Figure 6 gives a very good idea of the commercial set that has been developed for charging vehicle batteries. The rectifier set consists of four essential parts, namely, *panel, tube, holder,* and *compensating reactances.*

Panel

The panel with material mounted thereon requires a floor space of approximately 24 by 18 inches with a height of 76 inches. On it is mounted a voltmeter, ammeter, double-pole switches for connecting the panel to the supply circuit and the load circuit, and the necessary double-pole and single-pole switches for starting and operating the rectifier. Fuses and circuit-breakers are supplied for protecting the rectifier against over-loads. A starting resistance is mounted on one of the pipe supports and is connected in

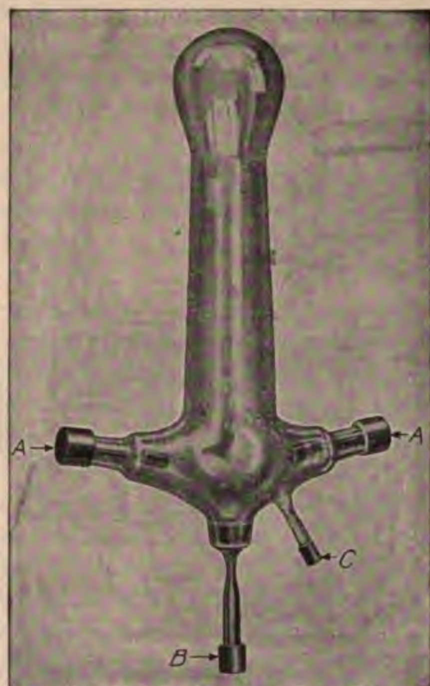


FIG. 7—MERCURY ARC RECTIFIER TUBE, REPRESENTATIVE OF 10, 20 OR 30-AMPERE SIZE

multiple with a pilot lamp mounted on the front of the board. The function of the starting resistance is to allow the rectifier to start before throwing on the load. The function of the pilot lamp is to indicate that the rectifier is in operation, and it also acts as a warning after the load has been thrown on that the starting resistance switch should be opened, as the lamp is dark when the rectifier is operating on the load only.

Tube and Holder

The tube (Figure 7) is an exhausted glass vessel, containing two anodes *A A*, one cathode *B*, and one starting anode *C*. The terminals are provided with metal caps which protect the electrodes, thus reducing to a minimum the liability to damage. The leads from the anodes are connected to the compensating reactance and the lead from the cathode to the load.

The holder consists of a moving member mounted on the face of the panel and provided with spring clips for holding the tube. Terminals for connecting the various parts of the tube to the panel are mounted on the panel.

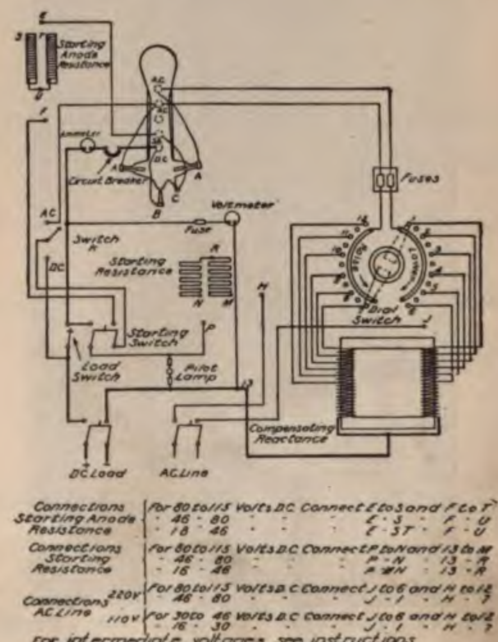


FIG. 8—DIAGRAM OF CONNECTIONS OF MERCURY ARC RECTIFIER PANEL SHOWN IN FIG. 6

Compensating Reactance

The compensating reactance (Figure 6) is connected directly across the alternating-current supply mains and is mounted either on the back of the panel or stands on the floor under the panel. Leads are brought out from the reactance to a dial switch mounted

on the front of the panel. By means of the dial switch the voltage and current may be varied within the limits of the rectifier.

Capacity

The rectifier is now furnished in three standard sizes, namely, 10 amperes, 20 amperes and 30 amperes. The above covers rectifiers with a single tube. As many as desired may be operated in multiple by the addition of certain auxiliary apparatus.

Frequency

The rectifier can be adapted to any commercial frequency, and the standard outfits will operate satisfactorily on any frequency from 25 to 140 cycles, inclusive. They are designed primarily, however, for 60 cycles, and the maximum direct-current voltage obtainable when operated at 25 cycles will be slightly higher, and when operated at 140 cycles slightly lower than when operated at 60 cycles.

Voltages

The rectifier can be furnished to operate on any secondary commercial alternating voltage. The standard outfits, however, are designed for operation on either 110 or 220 volts alternating-current, 60-cycle, single-phase circuits. It has been found, however, that for a range of direct-current voltage from 45 to 115, 220 volts alternating current will give the best results, while for a range of direct-current voltage from 16 to 45, 110 volts alternating current is most satisfactory. For practical purposes the direct-current volts may be considered to range from 20 per cent minimum to 52 per cent maximum of the alternating-current volts, while the alternating current may be considered as ranging from 40 per cent minimum to 66 per cent maximum of the direct current delivered. The range of direct-current voltage is obtained by the manipulation of a dial switch mounted on the panel.

Efficiency

As the loss in the arc is constant, the efficiency of course varies with the direct-current voltage delivered. For example, tests have shown the efficiency of a 30-ampere set, operating from a 220-volt, 60-cycle, alternating-current circuit, to be over 75 per cent from one-quarter to full load at a direct-current voltage

averaging 80, and over 80 per cent for direct-current voltage averaging 112. It will be noted from this that the efficiency holds up very high down to one-quarter load, which is not true in the case of motor-generator sets. At the same delivered direct-current voltage, practically the same efficiencies would hold on the 20-ampere and 10-ampere sets.

The above figures are cited to give an idea of efficiency, as the detailed figures vary with the direct-current voltage, which means with every connection of the reactance.

Power Factor

Under the same conditions of test as gave the efficiencies enumerated above, the power factor averaged approximately 90 per cent. It is of special interest to know that this high-power factor is practically maintained, whether a low-voltage battery or a high-voltage battery is being charged.

Effect of Wave Form of Rectifier on Storage Batteries

The question has been raised as to whether or not the pulsating direct current obtained from the rectifier would have a detrimental effect on storage batteries. This question has been submitted to a storage battery manufacturer and a reply has been received to the following effect: In regard to the effect on a storage battery of charging it through a rectifier, we can not see how it can possibly do any harm; in fact, we should infer that charging through a rectifier would be more efficient than from a continuous current, as the pulsations would, if anything, allow more time for chemical action, gassing would be less, and there would be less loss of energy.

Inherent Regulation

The rectifier has an inherent regulation of from six to eight per cent with variations of direct current. This inherent regulation is a decided advantage. As the storage battery is charged, its counter e.m.f. increases, which, with constant alternating-current voltage supplied to the rectifier, would tend to reduce the current flowing through the battery. As the current decreases, the voltage of the rectifier increases, thus tending to compensate for the increase of the counter e.m.f. of the battery. If this inherent regulation did not exist, the regulating switch would have to be moved more frequently during charge.

Maintenance and Repairs

The only part of the rectifier set that can require maintenance is the tube. The life of the tube under normal operating conditions is at least 400 hours. It will be readily appreciated, from your knowledge of the difficulty of arriving at the average life of incandescent lamps, that a considerable period of test is required to get an average life figure of the rectifier tubes. Tests at present indicate that the average life will be considerably above the figure just cited. This will be appreciated from the fact that we have obtained tests of 3000 hours on the 10-ampere tubes, 2500 hours on the 20-ampere tubes, and 700 hours on the 30-ampere tubes, these tubes still being in operation and having been operated continuously at their rated current. The figure on the 30-ampere tube is a little misleading, due to the fact that tests have not been carried on as long on the 30-ampere tube at the rated current as on the other tubes; in fact, not long enough to indicate that the life will be any shorter than the figures given on the 10 and 20-ampere sizes. Tests have been obtained on 30-ampere tubes running at an average of 25 amperes, of 1500 hours' life.

As the cost of renewals is merely nominal and the other advantages of the rectifier are so numerous, the question of life is not at all serious, but in any case, the saving in cost of energy due to the higher efficiency of the rectifier set over a motor-generator set is sufficient to pay for a new tube in approximately 300 hours, even in the case of a moderately low voltage battery.

Below is a single example of the saving in cost of operation of the mercury arc rectifier set over a motor-generator set, when charging a 44-cell battery, the battery being charged in accordance with time and current recommended by the manufacturer.

Motor-Generator Set

First part of charge is at 28 amperes and 106 volts (average) for 5 hours.
Efficiency of set at this load = 62 per cent.
Second part of charge is at 12 amperes and 108 volts (average) for 2 hours.
Efficiency of set at this load = 36 per cent.

$$\text{First part of charge} = \frac{28 \times 106 \times 5}{62 \text{ per cent}} = 23.93 \text{ kw-hours from service mains.}$$

$$\text{Second part of charge} = \frac{12 \times 108 \times 2}{36 \text{ per cent}} = 7.20 \quad \text{"} \quad \text{"} \quad \text{"} \quad \text{"}$$

Total, 31.13 kw-hours from service mains.

When figured at 6 cents per kw-hour = 31.13 × .06 = $1.867 per charge.

Mercury Arc Rectifier

First part of charge $= \dfrac{28 \times 106 \times 5}{80 \text{ per cent}} = 18.5$ kw-hours from service mains.

Second part of charge $= \dfrac{12 \times 108 \times 2}{81 \text{ per cent}} = 3.2$ " " " "

Total, 21.7 kw-hours from service mains.

When figured at 6 cents per kw-hour $= 21.7 \times .06 = \$1.302$ per charge.

Cost per charge motor-generator set	$1.867
" " " mercury arc rectifier	1.302
Saving per charge,	$0.565

Assuming the minimum life figure of 400 hours:

Seven hours per charge equais 57 charges during life of tube. Total saving during life of tube $= \$0.565 \times 57 = \$32.20$.

FIG. 9—ONE OF THE EARLIER INSTALLATIONS OF SINGLE-PHASE MERCURY ARC RECTIFIERS CHARGING AN AUTOMOBILE

In this particular example at 6 cents a kilowatt-hour, the saving is sufficient to pay for a new tube in about 124 hours.

General experience has shown the rectifier to be durable and satisfactory in its operation. If the central station will take up the rectifier for such purposes as described above and push its

use, a considerable increase in load will unquestionably result, as well as an improvement in the load factor.

To enable a clear presentation of the subject of the mercury arc rectifier, and to avoid confusion, I have limited the discussion to one application of the rectifier, namely, the rectifying of alternating current for use in charging storage batteries, primarily for vehicle purposes. It can, of course, be used for charging batteries for other purposes, such as for electric launches, central energy telephone stations, *et cœtera*.

One of the most important, if not *the* most important application of the rectifier is in connection with furnishing direct current for the operation of series direct-current carbon arcs, series mercury arcs, and series luminous arcs or magnetite lamps for series street lighting. The valuable characteristics of the magnetite lamp were presented to your convention in 1904, and doubtless are appreciated by all of you, as is also the fact that direct current is necessary for its operation. In the past this has been a disadvantage, necessitating the installation of revolving machinery, such as Brush machines. The mercury arc rectifier makes possible the operation of the magnetite lamp from the well-known constant-current transformer, the alternating current of which is rectified into direct current by the mercury arc rectifier. Such a system of street lighting has been operated by a central station for some time with remarkably satisfactory results. It will readily be appreciated that this means a revolution in street lighting.

DISCUSSION

MR. WAGONER: As the rectifier is new to some of you at least, I have installed a set that has been developed for charging vehicle batteries. As it is connected up I will start it.

(Mr. Wagoner then described and demonstrated the operation of the rectifier.)

THE PRESIDENT: Is there to be any discussion on this paper?

MR. W. H. BLOOD, JR. (Seattle, Wash.): I ask what drop in voltage you have before the arc will break.

MR. WAGONER: That varies somewhat with the size of the tube being used. A 10-ampere arc is not so stable as a 20 or 30-ampere arc. With the 20 or 30-ampere size we have not found

that any fluctuations likely to occur on commercial circuits will put the arc out. On a 10-ampere tube the fluctuations may be sufficient to put the arc out, and if restarting the tube under these conditions is a serious matter the outfit can be furnished with an automatic starter to restart the tube when the voltage has settled down to standard. We feel, however, that the automatic device adds a slight complication that in 90 per cent of the cases is entirely unnecessary, and therefore we do not furnish it as part of the standard outfit.

MR. DOW: Is there any possibility of a direct current kicking back in an automobile-charging device?

MR. WAGONER: If the counter-electromotive force of the battery rises above the voltage of the tube, the arc simply goes out. The tube itself is an automatic reverse-current relay. The battery can not discharge back through the tube.

THE PRESIDENT: Before proceeding with the next paper, Mr. Scovil, of Cleveland, presents the following amendment to the by-laws, which I will refer to a committee, as it is desired to have action taken on the same at this convention:

Amend Section 3, Article IV, by adding at the end thereof the following: *The retiring president shall, by reason thereof, be a member of the executive committee for one year after the expiration of his term.*

THE PRESIDENT: I will refer the proposed amendment to Mr. Henry L. Doherty, Mr. H. T. Hartman and Mr. George W. Brine. They were the members of the committee having in charge the matter of amendments last year.

THE PRESIDENT: We will consider the next three papers together, as they all relate to practically the same subject. The first is the report on advertising methods, Mr. Percy Ingalls, of Newark, N. J., reporter.

Mr. Ingalls presented his report.

ADVERTISING METHODS

IN collecting material for a report on Advertising Methods, I received in reply to my circular, responses of every kind. Some companies are advertising considerably, others confine their efforts to limited space in the newspapers, while still others do no advertising.

Many of these replies disclose a strange apathy on the subject, which is remarkable in this age of advertising where almost everything is attractively presented.

Some of these letters, confessing to limited or no experience in advertising, were written apologetically, making it apparent tha central station interest is present, though dormant in many places, and that it is undoubtedly due to lack of time that this essential adjunct to the commercial department has been neglected. Advertising is an art in itself, and, as few men are born artists, the efforts of the operating man along these lines have not always been successful. As it requires time and thought, it has been allowed to rest, awaiting the day when operating troubles should cease and more time could be devoted to commercial questions.

On the other hand, the companies that are advertising sent in so many good plans and copy that it was found difficult to select that which would best illustrate the popular methods, and it has been necessary to leave out of this report many striking examples of advertising. In last year's very interesting paper by Mr. Vredenburgh, the various methods then in use were so clearly indicated, and in the interim there have been so few innovations, that I can only attempt to bring the subject up to date and show which plans have grown in popularity and how the progressive and aggressive adver-

tising of to-day is being done.

From the material received, it would appear that the newspaper has not lost its lead as the most used method of publicity, for the companies who are large advertisers in other ways continue their newspaper advertising while many others use the papers exclusively. The popularity of monthly bulletins has increased during the year and there are several new publications in the field. Personal letters, monthly calendars, and novelties, artistic, quaint and catchy, on the subject of signs, store lighting or power, form the basis of follow-up campaigns which are being conducted by many of the large companies, and it is here that the greatest progress has been made. All of these methods, assisted by street car advertising, electric signs, illuminated bill-boards, and folders enclosed with monthly bills, combine in making up the really aggressive advertising of to-day.

Newspapers

In newspaper advertising, there is often the feeling that if the advertising man had his way this money would be spent on other methods aimed more directly at the desired class of customers, but the fact must be

remembered that newspaper advertising often accomplishes a double mission, for, aside from its undoubted value to the company, it establishes friendly relations with the press. Newspapers as a rule are also good consumers, even if many small and some large ones do cling to the old fashioned way of trading advertising for the daily necessities of the editor or of the paper. Of course, no one, least of all the lighting company, can deny that light and power are necessities, so it frequently happens that considerable space is used for the purpose of working out bills. For this reason, newspaper advertising is often done half heartedly and without proper consideration, where, if due attention were given it, it would easily prove of greater value to the company than the light or power furnished.

In preparing newspaper advertisements, consider:

First, the branch of your business to be advertised. If you desire to aid any specific campaign, such as residence lighting, fans, etc., devote the space to the subject. Make your advertisements appeal to the greatest possible number of people, which ordinarily means a talk on household necessities. Limited classes, such as manufacturers or professional men, can be

The Pioneer Electric Bulletin

reached in a more direct and less expensive way by letter and booklet. The second consideration is the location. This should be selected carefully with special reference to the class of people you want to reach. An advertisement should not be hidden on the worst page in the paper because the rate happens to be cheap. Newspaper advertising, like everything else, is only successful where it is done carefully, continuously, displayed attractively and changed frequently.

Monthly Bulletins

Monthly Bulletins, touching on electrical subjects of general and local interest, have grown in favor, and there are now nine well established publications which have come to your reporter's notice. The *Edison Bulletin* of the New York Company, the pioneer in the electrical field; the *Brooklyn Edison* of the Brooklyn Company; *The Electric City* of the Chicago Company and *The Edison Light* of the Boston Company, have all been continued and have grown in size and value. On April 1, 1904, the United Electric Light and Power Company of Baltimore issued for

the first time their *Notes on Electric Service.* On July 1, 1904, the Public Service Corporation of New Jersey followed suit with *Light and Power* "devoted to electricity, the world in general and New Jersey in particular." This bulletin has grown from a pamphlet of eight to one of sixteen pages and from an issue of five thousand to one of over ten thousand each month. This was followed on October 1, 1904, by *Current Talk* published by the Buffalo General Electric Company. On November 1, 1904, by *The Illuminator* published by the Cleveland Electric Illuminating Company, and recently by *Electric Light and Power* published by the Union Electric Light and Power Company of St. Louis. All of these publications are alike educational in character, dealing with electrical matters of general and local interest, reproducing photographs of attractive lighting effects obtained by customers and of noteworthy power installations, and bringing out prominently the fact that central station service is used in all important buildings, the owners finding it cheaper and more satisfactory than the generation of their own current.

Bulletins are sent to users of current as well as to prospective users, and afford a very satisfactory means of communication between the company and its customer. At the same time, the examples of lighting, power, etc., shown are object lessons to possible customers who are thus kept informed of the advance in electricity and of its special features as found locally.

The Electric City which is published in larger form than any of the other bulletins, while bringing out all the points covered by the others, makes a specialty of cartoons and devotes considerable space to humorous articles. In this way, interest is kept up and the paper enlivened.

Notes on Electric Service is devoted to a special topic each month; in this it differs from the other bulletins.

Some companies issuing bulletins have adopted the plan of publishing advertising lists of reputable wiring contractors, manufacturers of motors, signs, etc., on the back cover, thus furnishing prospective customers with information as to where to go for wiring or apparatus.

Nearly all of the companies publishing bulletins consider them the most important feature of their advertising. In this connection, Mr. Williams, of the New York Edison Company, says:

"The Bulletin is the first and probably the best in that it says just what we want to say and to the people whom we want to reach—the important building owners, the operators of private plants, the architects, builders, and all others who are prospectively interested in our service. It enables us to show the variety of the service that can be obtained from our mains. It suggests the enormous resources of the company, and to the one most important class of our customers, the large users, it contradicts the state-

Samuel Boone, Jr. & Co.
Up-to-Date Ideas in Printing
Baltimore, Maryland

East Pratt Street
Maryland Telephone

March 22, 1905.

Consolidated Gas, Electric Light and Power Co., City.

Mr. Douglass Burnett, Mgr. Elec. Dept.

Dear Sir--We have found the individual adaptation of electric motors to printing presses the most sensible, practical, economical and rent-saving proposition which we have ever handled. We have had more satisfaction, increased our productive capacity with the same amount of facilities, utilized space formerly occupied by line and countershafts for other purposes, such as stock shelves, &c., had less dust and dirt, thereby producing a cleaner and better class of work, and maintained a more sanitary and hygienic condition in the workshop. We investigated the question of electric power (especially the individual motor) very thoroughly before installing same, having used the gas engine previously, and are more than gratified with the results, and thank you for the company's uniform courtesy and promptness in the service rendered us.

Very respectfully,

Samuel Boone Jr. & Co.

An Example of Good Advertising

Advertising Novelties Used by Several Companies in Follow-Up Campaigns

ment in which engineers take so much delight—that the service of the central station is necessarily confined to the small user."

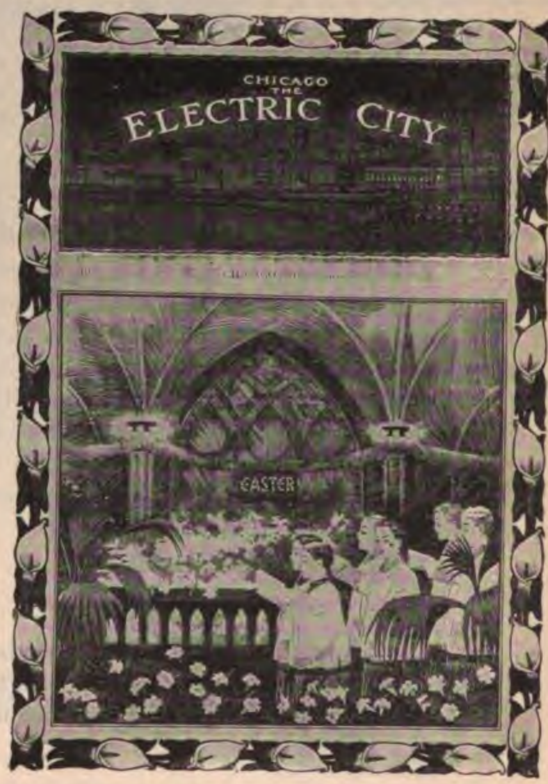
As part of a follow-up campaign, circular letters on specific subjects, such as signs, store lighting or power are frequently and successfully used.

Letters, including name, address and signature, may be reproduced at small additional expense by patented processes which will give every appearance of copied original letters. This inexpensive method of advertising is proving of great value, for a letter well written and signed by

a person in authority will always command attention. The topic should be presented briefly, clearly, and as a business proposition. Several of the follow-up letter campaigns include letters from different officers of the company, each succeeding one coming from a little higher up in the official scale, thus leading the prospective customer to believe that the entire staff of the company is interested in getting his business. These contain a personal touch and the several names signed add weight. Testimonial letters are also used effectively as part of the follow-up campaign, and some reproduced on the writer's own letter head are valuable as showing what others think of your service. This method finds greater favor with many companies than that of reproducing a number of testimonials in pamphlet form, for a single letter is much more apt to receive attention.

Novelties

There has probably been no greater development during the past year in any branch of advertising than in the follow-up campaigns which include the use of novelties. Their use has become justly popular for they open a field of unlimited possibilities where the imagination of the advertising man comes into full play.



Novelties are usually in the form of mailing cards, booklets of unique design, or of folders, and are used as an auxiliary to the heart of the campaign—the circular letter. Illustrations showing a few of the best examples submitted are reproduced. It is unfortunate that the text of these cannot be given.

EDISON
ELECTRIC ILLUMINATING COMPANY
OF BROOKLYN
General Office. Edison Building

BROOKLYN, NEW YORK March 25, 1905.

Acme Furniture Company,
Brooklyn, N. Y.

Gentlemen:

We have not heard from you as yet in regard to our proposition to supply you with an electric sign and install it on your premises (including wiring) free of charge.

As the time that this proposition will be open to Brooklyn business men is limited, if you desire to take advantage thereof it would be advisable to let us hear from you on the subject without delay. Fill out the enclosed post-card and our representative will call and supply you with every detail on the subject.

The recent reduction in retail rates for Electric Lighting has decreased the cost of operating Electric Signs by from 20 to 30 per cent.

An all metal panel sign with 24 incandescent lamps may now be illuminated for as low as five cents per hour.

The best advertisement is the one which attracts most attention to your place of business. An electric sign does just that. Besides it adds tone and an up-to-date appearance to any establishment. Hundreds have already taken advantage of the Edison Co's liberal sign offer and are now nightly burning their names into the public mind. They form a progressive procession on the road to success.

Do you care to join?

Very truly yours,
A. A. Breman
Secretary.

(c)

Calendars

Public Service, so far as the writer knows, is the only company using monthly calendars. These are part of the electric power follow-up campaign, and, being small and attractively lithographed in colors, have been well received.

The calendar, as a novelty, has a decided advantage over others, in that it may be made equally attractive and being a calendar, is more apt to be preserved. Concealed in each device is a small circular telling of the merits of electric power and the benefits derived.

Street Car Advertising

I have been unable to find much interest among station managers in street car advertising, and as this means of publicity has always been popular with other advertisers, its limited use must be due to its expense. The Minneapolis General Electric Company reports that it has advertised in the cars to a limited extent but with considerable success. This method has also been successfully employed by Public Service.

Electric Signs

So many companies are now advertising or are considering the possibilities of sign lighting as a new and lucrative branch of their business that it

is strange more attention is not given to the use of signs to advertise electricity.

The Philadelphia Electric Company has several illuminated signs in use in prominent locations and reports very satisfactory results.

The Boston Edison continues to use a Mason Monogram Talking Sign with good results.

The Public Service has used for some years on all its principal offices electric signs giving the name of the company. These, however, are now being supplanted by permanent signs of changeable letters with which

Cleveland, Baltimore, St. Louis and Buffalo Bulletins

Public Service Office, Newark, N. J.

Market Street, Newark, N. J., at Night, Showing Result of Free Sign Campaign. Fifty-two Signs in Five Blocks

Public Service Office, Newark, N. J.

Market Street, Newark, N. J., at Night. Showing Result of Free Sign Campaign. Fifty-two Signs in Five Blocks

office, and electric companies would do well to follow the lead of many of the gas companies who devote considerable space to the display of apparatus.

In this connection it is interesting to note that the Chicago Edison Company is still successfully using its movable electric cottage, although it reports that it will probably be given up soon on account of its having become so well known to the residents of Chicago that it has lost much of its original drawing power.

In the expenditure of an advertising appropriation, the results attained are what count. The advertising department must be inseparably linked to the soliciting department or the campaign is bound to fail. In other words, judicious advertising plus salesmanship will accomplish definite results. Thousands of dollars have been thrown away by electric companies in injudicious advertising. Modern advertising methods bring the salesman in touch with the prospective customer.

In the foregoing description, I have attempted to indicate the forms which successful electric advertising takes without going into results and in taking up this all important part of the subject am obliged to use the facts and figures with which I am familiar.

THE EDISON ELECTRIC ILLUMINATING CO.
OF BOSTON.
General Offices, 3 Head Place.

Boston, Mass., April 15, 1905.

E. A. Gibbons,

Boston, Mass.

Dear Sir:

The subject of electric power is not one to be treated lightly. Either an electric motor would be a good thing in your business or it would not.

If a motor would save money for you--if it would give you the number of horsepower of useful power that you need at a lower cost per horsepower, all things figured in--then you ought to know it.

For my own part the economy of electricity in driving machinery is plain. That is natural. I can see just <u>why</u> it saves money--just where the saving comes in.

I know from practical experience just how much it costs to manufacture power by the various methods. I know where the leaks are, and where an electric motor stops them.

Of course you cannot be expected to see things as I do. You are probably not as close to the power problem as I am--your business is different. But I have a representative who is a thoroughly expert power man, and I am sure it would be worth your while to talk with him on the subject.

I would be glad to have him call on you if you are willing, and enclose a return postal for your convenience in making an appointment.

Very truly yours,

Wm. H. Atkins

General Superintendent.

An Advertising Campaign

In outlining a definite advertising campaign during the early part of 1904, the advertising department of Public Service first put itself in close touch with the sales department. Then three dis-

Some Denver Gas and Electric Company's Novelties

tinct campaigns were outlined for electric power, electric signs and residence lighting. Old mailing lists were carefully revised by the solicitors in the various districts and the new campaign opened with small but workable lists for each department.

Street Car Card

Light and Power, the monthly bulletin, was made the basis of all of these campaigns; in other words, not only prospective customers but present customers received this publication, as it constantly kept them in touch with the new things in the electrical field. A series of circulars, booklets, and mailing cards, were devised and every prospective customer received one of these at least once in two weeks. The *fac-simile* letters carried the signature of the local agent and with every piece of printed matter there was always enclosed a return post-card; sometimes stamped, sometimes not, and upon several occasions, stamped envelopes were used to stimulate a reply. From time to time, the new ideas brought in by the solicitors were incorporated in this literature and it was the constant endeavor of the advertising department to keep all of these devices and letters up to date. At first, the sales department were very luke warm over the advertising proposition, believing that it would rob them of some of their glory, but as the campaign progressed from week to week, the solicitors began to realize that this advertising was materially aiding them in their work, thereby proving a direct benefit. This campaign covered

cities and towns of varied population, but the proportionate results attained showed that advertising conducted in the proper channels was as productive of results in the town of five thousand as in the city of three hundred thousand population.

A comparison of the new business secured in Public Service territory in 1903 and 1904, will show the efficiency of the new plan as outlined.

In 1903, 35 electric signs were installed throughout the Jersey territory.

In 1904 through direct advertising and aggressive salesmanship, 452 signs were installed, over twelve times as many. In explanation of these figures, however, it was not until 1904 that the company commenced to give free signs.

PUBLIC SERVICE CORPORATION OF NEW JERSEY
ELECTRIC DEPARTMENT

Perth Amboy, N. J. April 15, 1905.

Mr. W. W. Kain,
Perth Amboy, N. J.

Dear Sir:

During the year 1904, in Public Service territory, over 5,000 H. P. in Electric Motors, was installed. This insured to nearly eight hundred well satisfied firms an increased out-put at a minimum cost.

We believe that had you looked into the subject last year, you would now be equally pleased with the results.

After investigating the question, you can't fail to see that the continued use of any other power is pursuing the penny-wise and pound foolish policy.

Electricity is the power of the present. By belting and shafting, one motor will run any number of machines or appliances. A direct connected motor - where it's use is practicable - is the acme of perfection in power. Either occupies little space, makes no ashes and is ready for work on the instant, thus economizing in space, labor and time.

Don't you think such a proposition worth looking into, especially as we sell motors at cost and give you the wiring.

Our representative, on receipt of the enclosed post card, will be pleased to go over the subject and consider your special needs. His estimates will cost you nothing.

Yours truly,

W. A. Belcher

Agent.

LIGHT THAT'S RIGHT

ELECTRIC LIGHT IS RIGHT

for Home, Store or Factory. Ready in an instant. Cut off when not needed.

ELECTRIC DEPARTMENT,
PUBLIC SERVICE.

Street Car Card

Specimens of Newspaper Advertising

In 1904, 4,895 horse power in motors were installed.

During the same period 7,203 new customers were added; 2,183 arc lights installed, as were also 170,141 sixteen candle power incandescent lights.

In considering these several methods of modern advertising, it should be remembered that all successful efforts have been and always must be continuous to be effective and that any campaign (no matter how modest) should be laid out in advance and continued to a successful end. If the amount obtainable for advertising is small, start in a small way, but keep it up—watch it, nurse, and get the most for your expenditure. Small drops of water will undoubtedly wear away a stone but it necessarily takes time. Consider your subject and select your copy carefully, prepare it thoughtfully, and if in the newspapers change it often, but keep to the point and "time will tell." If you decide upon the follow-up campaign, remember that the road to success lies almost as much in the preparation of mailing lists as in the advertising itself, for carelessly prepared lists are expensive and are often the cause of good advertising proving ineffectual. It is better to have a small growing list than a large dead one. After a prospective customer has once been placed upon the list, his name should be kept there until he is dead or gone out of business. That man is always a possible consumer of electricity. No inducement could get him to sign a contract to-day, but six months from to-day conditions may have radically changed and he may be very glad to become a customer of the lighting company. "Keeping everlastingly at it brings success," is the trade-mark of one of the prominent eastern advertising agencies. This motto can

From Boston Papers

as well be applied to the advertising and new business campaigns of central stations. Judicious advertising will sell electricity just as quickly as it will Quaker Oats. Do not become faint hearted, but lay aside a certain percentage of your gross receipts, spend it for printer's ink, back it up with competent salesmen and your earnings will show a handsome increase from year to year. Well

A New April Fool Joke

Cartoon from Chicago Electric City Bulletin

equipped stations and low operating and distribution costs receive a vast amount of attention, but unless the product of these stations is sold to advantage there will be no dividends. To reap the best results, therefore, commercial matters should receive their full share of attention and there is no doubt but that advertising plus salesmanship will sell electricity.

OFFICE OF
UNITED ELECTRIC CO. OF NEW JERSEY

Newark, N. J., April 11, 1905.

Mr. Chas. H. Greenberg,
Newark, N. J.

Dear Sir:-

I have just completed a perusal of our sign records and find that, as yet, you have not installed an Electric Sign. This must mean that you have not thoroughly investigated it's merits as a method of publicity, the life of trade.

An Electric Sign is not a luxury, it is an investment which pays a big dividend in increased custom.

It will attract more attention to your place of business than the use of newspaper space or printed matter.

An Electric Sign is in itself a follow-up system, a continual reminder, that pounds away for eighteen or twenty hours out of every twenty-four.

During the day it answers the purpose of any good sign, at night it is a blazed trail direct to your door. It burns an indelible impression of your hustling qualities on the mind of the passing public.

Last year this Company erected over four hundred and fifty signs for progressive business men.

We have a free sign proposition to offer which, I sincerely believe, you will want to consider.

Write, on the enclosed card, a convenient hour for our representative to call and he will explain the details.

Yours truly,

H. P. Chandler

Gen. Agt.

Fac Simile Letter
Used in
Electric Sign
Advertising Campaign
of
Public Service

THE EDISON ELECTRIC ILLUMINATING CO.
OF BOSTON.
General Offices, 3 Head Place.

Boston, Mass., April 15, 1905.

Mr. J. Z. Quinot,
Boston, Mass.

Dear Sir:

The letter you intended to write me some time ago has not yet reached me.

I am sure you must have overlooked it--the matter was important, and I venture to recall it to you in the hope that you are now ready to take it up.

You were thinking about an electric sign--considering whether or not it would pay you to put up one.

Electric signs must pay--there cannot possibly be any other reason for the enormous increase in the number of them in use, here in Boston. There is something about them that positively draws trade--something more than mere advertising value--something vitally attractive and compelling.

Those who have put them up do not take them down again; they write us letters stating in emphatic terms that their trade has increased. We'll show you the letters if you say so.

Can't you give our representative a few minutes in which to tell you the trifling cost of some of our signs?

Your pen is handy--so is the enclosed postal.

Very truly yours,

Wm. H. Atkins

General Superintendent.

W.H.A./3

One of a Series
of Letters
That Sold a Large
Number of Signs
for
Boston Edison Co.

Proofs of Detroit Newspaper Ads.
The Edison Company Use this Method Exclusively

Press of
PUBLIC
SERVICE
Newark,
N. J.

The President: We will now have the report on sign and decorative lighting, by Mr. LaRue Vredenburgh, of Boston.

Mr. Vredenburgh not being present, the report was read by Mr. C. W. Lee, of Newark, N. J.

SIGN AND DECORATIVE LIGHTING

Your reporter desires to consider the subject of Sign and Decorative Lighting from an entirely practical and matter-of-fact point of view, presenting what must be designated as more of a paper on the subject than a report embodying data obtained from member companies of the association.

The reports on this subject submitted at the conventions of 1903 and 1904 were so carefully and ably prepared, so handsomely and profusely illustrated, and altogether so artistic and exhaustive, that your present reporter despaired of being able to follow along similar lines without being hopelessly distanced by his pacemaker, and, consequently, with the entire absence of illustrations, will endeavor to deal with the subject from the standpoint of the lighting company, that soulless entity which looks at all things through commercial glasses and prizes all undertakings in exact proportion to their money-making capabilities. In other words, your reporter desires in this paper to avoid entirely the artistic and æsthetic, and to deal with the subject of sign and decorative lighting from its purely commercial side.

It is undoubtedly a safe assumption that the business world recognizes the increased drawing force of an illuminated sign over a plain one, not only on account of the additional hours of its usefulness, but also on account of the attractive efficacy of light. With this assumption granted, the central station desiring to increase the number of its sign customers has a good proportion of its work already accomplished, for there is no need of entering into an argument to establish the superiority of its commodity. The only thing necessary for the salesman to do is to convince the prospective customer that an electric sign on his place of business will add to its attractiveness sufficiently to justify the necessary outlay, and by "attractiveness" is meant power to attract and hold customers. This power to attract may consist of a variety of attributes. Some business houses attract solely by the quality of the goods offered; others by the beauty of their decorations or the artistic nature of their display; others by the

convenience of their location; others by courteousness and consideration of the wants and wishes of their customers; others by their prompt delivery of goods and the reasonableness of their prices.

The chief power of such attributes is to hold customers after they have been secured. The enterprising merchant, however, is not satisfied with simply holding his own; he must be continually adding to his own or retrogression follows. Hence there is a constant and ever increasing demand for methods, the use of which will bring new trade, and here opens the limitless field of advertising with its numberless methods and inexhaustible means. It is desired here, however, to consider only the value of electric signs and decorations, and these not so much as advertising mediums as important features of a central-station demand.

There can be no question of the increasing demand for and appreciation of the electric sign. A comparison of the present appearance of the streets of any city in the country with their appearance a few years ago emphatically attests the public appreciation of electric light, not only in signs, but also in window decorations and in general illumination. One of the large lighting companies has more than trebled the number of its sign customers during the last year and a half, another has increased its sign business thirty-three and a third per cent within a year, having added about six hundred signs of all sizes. This company has adopted the policy of supplying and installing signs free of charge under contract, provided the customer will agree to keep the sign a certain length of time and burn it either fixed hours or a certain stipulated amount as governed by a minimum bill. In most of the signs so put out by the company referred to 4-cp lamps are used, although in some cases 2-cp lamps are used, and in a few lamps of larger candle-power are installed. The consensus of opinion seems to be that 4-cp lamps are the best for general sign illumination. In most of the larger cities the majority of signs burn until midnight, but some of the companies have a ten o'clock switching hour, and most of the signs that burn upon meter do not average as late as ten o'clock.

One thing that has acted as a decided handicap to the introduction of electric signs in many cities and towns is the restriction placed by ordinance on the size and position of signs. In many cases they are prohibited from projecting more than two

feet from the building line. In general, these ordinances were enacted before the value of electric signs to the municipality itself was fully realized. A little properly directed effort on the part of the lighting companies will undoubtedly tend to the correction of this condition, as the benefit accruing to any town from the added illumination of its streets by means of signs is so self-evident that but little argument is necessary. A revision of the antiquated ordinances regarding signs has been accomplished in Chicago; there is still a restriction as to size, and a license of a certain amount per square foot is levied annually to provide for a rigid inspection of hanging, *et cætera*. A certain minimum number of lamps is also required, in order to prevent anyone's putting up an immense board sign with just enough lamps installed for it to be called an electric sign. The ordinance also requires that the lamps shall burn until at least half after nine every evening, so as to insure the municipality's receiving the benefit of the illumination. There is no doubt that a large number of the cities and towns in this country could be induced to enact similar ordinances. It would certainly be the means of making the cities much more attractive, and would give the lighting companies a greatly augmented revenue.

The method pursued by one of the large companies last year was a persistent and systematic advertising campaign by means of letters, folders, mailing cards, booklets, return postal cards and enclosed stamped envelopes, sent to a selected mailing list secured by a thorough house-to-house canvass, including all retail merchants in all lines of business whose stores were sufficiently pretentious to possess a plate-glass window. This campaign last year resulted in more than doubling the number of sign customers. The company referred to supplies 4-cp lamps for signs only. The above result was obtained in a city where an ordinance restricts the projection of signs to two feet from the sidewalk line, consequently most of the signs installed are either vertical or flat against the face of the building. Most of the large companies use electric signs for their own advertising, thus proving their faith in what they recommend to others; the effect of this is undoubtedly in the right direction.

The rather large initial cost of electric signs has always militated against their use, but recently manufacturers have been di-

recting their energies to the reduction of this first cost, with the result that some very effective signs are now on the market which may be purchased at a very reasonable cost. One of the recent improvements is the thermostat control, by means of which a sign is flashed without the use of a flashing switch. This is only practicable, of course, on comparatively small signs, mostly for interior use.

In some cases, as mentioned before, the lighting companies furnish and install signs free of charge, these, of course, of some standard make and type; in others the customers are required to pay for same in small monthly instalments. This can undoubtedly be done at a profit to the company, as signs are usually burned for long hours; and while part of this is on the peak of the load, a good proportion of it is at a desirable time, and companies should bear in mind that every sign installed is a distinct and emphatic advertisement of their business. Many commodities purchased by the public are taken away and used at home, or in other places where no one but the possessor sees them, but the electric sign is meant for purposes of display and advertisement, and not only advertises the owners, but also the maker of the sign and the company that furnishes the electricity.

One of the larger companies (and possibly others) has placed the sign business in the hands of one man, who is especially qualified by experience and study to handle this branch of the business. The great majority of merchants when considering the subject are completely at a loss as to what size and style of sign to adopt, and invariably consult the lighting company for advice in the matter. An expert should be able to advise the prospective sign customer in all matters of detail, and as the conditions are so varied and the possibilities so unlimited, judicious advice from such a source is of great value to both customer and company. No effort should be spared to insure the customer's installing the most efficient and most economical sign. It can readily be seen that there is an opportunity for the exercise of a great deal of ingenuity and good judgment in planning or selecting a suitable sign. The candle-power of the lamps installed should depend upon the location of the sign, whether same is intended for long-distance exposure, for interior use, or in narrow streets low down on buildings, where from the nature of the surroundings the sign may be seen but at a comparatively short distance.

So many matters of detail must be considered that the adoption of any standard type and style of signs is practically impossible. The lighting companies are naturally inclined to encourage the use of exposed lamp signs, as these consume the greatest amount of current; but there are a number of other types of signs that are much less expensive to construct and also to operate, such as illuminated boards, transparencies, *et cætera.* The value of a satisfied customer as a medium of advertising is universally recognized, and it is much better to equip a small customer with an inexpensive sign, which he can operate at a moderate cost and continue to operate for an extended period, than to persuade him to install an expensive one, the maintenance of which is more costly than the size and nature of his business would justify, for such an experience would naturally tend to prejudice him against the use of signs in general.

The subject of window lighting might justly be considered under this heading, as the conspicuous illumination of a show window has a distinct value apart from simply displaying the goods therein contained, for the well-lighted window attracts almost as much attention as a brilliant sign, and is the primary inducement tending to further investigation by stimulating curiosity. One notable case exists where a large store window is most strikingly illuminated with no goods displayed, nothing but cards and placards intimating what beautiful and attractive goods may be seen within. This might not prove altogether satisfactory as a permanent arrangement, but as a temporary change should prove effective, and might induce persons to enter in order to satisfy a curiosity which, were the goods in the window, would be satisfied without entering the store. Of course the main thing is to persuade people to come in—after that the salesman must do the rest. The Boston Edison Company has installed in its exhibition rooms a sample show window with five different schemes of lighting, illustrating the effect of concealed lamps, reflector lamps, overhead lighting, side lighting, Meridian lamps and various combinations of the above-named methods; this has undoubtedly been of service to customers in determining upon what method to adopt, and to the company's salesmen in advising customers along this line.

As to decorative lighting, while all light is inherently decorative, there is no artificial illuminant that lends itself so readily

to ornamental and decorative effects as does electricity. In fact, this is limited only by human ingenuity, and the improvements during the last few years along the line of handsome and artistic electric fixtures have been most marked. The possibilities along the line of extensive out-door decorative effects by means of electric lights have been most satisfactorily demonstrated at the various expositions held in this country during recent years. Probably the most effective and interesting display of this sort was made at the Pan-American Exposition at Buffalo. Conditions were particularly favorable there, and were taken advantage of to the fullest extent. Local out-door decorations in various cities do not appeal very strongly to the lighting companies, on account of their excessive demand for but a brief period, occurring usually at the time of the heavy normal load. They are, however, of value to the companies in opening the eyes of the public to the possibilities along this line. There is probably no system that lends itself so readily to this kind of work as what is known as the "Eblight" system, but its rather excessive first cost militates against its general use. This system is adapted equally well to interior decorations, and as this kind of work is something for which there is more or less of a constant demand the lighting companies may well afford to give the subject careful attention. The "Miniature Decorative Lamp sets" gotten up by the General Electric Company are admirably adapted to a great variety of interior decoration, especially to Christmas trees.

Another field that shows quite a promising crop for lighting companies is the illumination of bill-boards. These are generally controlled by advertising concerns, who are beginning to appreciate the increased value of their space when properly illuminated. This is also appreciated by the advertisers, for they realize that the illumination of a sign-board adds about five hours each day to its usefulness, and they are willing to pay for these five hours. Some of the lighting companies whose lines extend through country districts in reaching suburban towns are beginning to light the large bill-boards displayed along railroads and highways. This should be profitable lighting wherever the boards are within a reasonable distance of the company's lines.

Another type of sign which appeals strongly to the general advertiser is the so-called "talking sign." This sign, although quite expensive to install and only adapted to use in larger cities,

is of such versatility and attractiveness, enabling the user to present such varied and extended arguments, that it should prove a profitable investment. The lighting companies can not afford to overlook or neglect that branch of the business covered by sign and decorative lighting, for it has already assumed decided prominence and its future is almost unlimited. This is an advertising age, and the newer and more progressive methods are eagerly sought and adopted.

Respectfully submitted,

LARUE VREDENBURGH.

Mr. Lee then read his paper entitled *Free Signs and Flat Rates*, as follows:

FREE SIGNS AND FLAT RATES

Publicity is the commercial watchword of to-day. Through divers channels millions of dollars are annually being poured in an effort to reach the buying public. That these efforts are productive of results can not be gainsaid. The various methods followed in the outlay of this vast expenditure can be summed up in the one word—advertising.

By the united efforts of publisher and advertising agent the merchant and the manufacturer have been educated into spending a certain percentage of their gross income for publicity. Lighting companies should be deeply interested in and be an aid to the development of this wonderful field of advertising, because of the outlet it offers for the sale of current, which they can readily produce after the present peak hour.

While it is my desire to consider only one phase of the advertising subject—that which relates to the possibilities presented in the use of electric signs as a means of obtaining long-hour customers—yet the entire field when properly developed, as it can be, means an added stimulus to window lighting and closely in its wake will come increased store lighting.

In the development of electric lighting numerous new difficulties are constantly being presented, while but few of the old ones have been left behind. Of these accumulated troubles the majority, in one way or another, apply to that bugbear of all lighting companies, the peak hour. Try as we may, none of us has succeeded in persuading one-half of the public to use current during the day while the other half uses it at night. True, the development of the electric motor and the invention of numerous current-using devices have had a direct bearing upon making the station load more uniform, but at best they have only helped out during daylight, leaving the hours of darkness still to be taken care of.

As it is impossible to induce the use of current when it is not needed, and as we are now supplying the present wants of our customers, it remains for the central-station managers to discover new needs and educate the public to accept them. Current for illuminating purposes does not present the proper outlet, for this business is already ours, but the great field of advertising with

its limitless possibilities offers many attractions. Here is long-hour burning with the hardest of the missionary work already done. The manufacturer and the merchant are ready and willing to spend money for advertising, but the lighting companies, with a few exceptions, are receiving but an infinitesimal share of the appropriations.

Neither the great general advertiser nor the small store-keeper should be overlooked in an aggressive sign campaign; one has billboards to illuminate, the other a store front. By the introduction of aggressive methods electric companies can fill the night world with light. Why not seize upon this field? Tackle it with vigor. Give signs away, or, rather, loan them to your customers. Don't use half-hearted methods and try to sell them because of the fear of possible losses in the lending. Changeable and inter-changeable signs are cheap, and by their universal use you can absolutely prevent losses.

I am familiar with the methods of a lighting company, covering a well-populated but scattered territory, which at the beginning of 1904 had less than 50 signs connected. This company adopted the free-sign proposition, gave away two standard types of signs, both of which were changeable, and at the beginning of 1905 had over 450 connected, containing a total of 29,749 four-cp lamps, returning an annual revenue of $59,130.48. This company charged off the first year the cost of constructing signs of changeable letters, as well as all erecting and connecting cost; together with 20 per cent depreciation on the sign, 5 per cent depreciation on station, line, meter and transformer investment. Charging the current used at cost, with lamp renewals and maintenance, it earned from 10 to 50 per cent on the investment for each sign and its pro rata station and line cost.

Many of these signs are now on their second year's burning. This year's profits will be much greater, because all construction, wiring and erection items were charged against the first year. A few customers were lost at the expiration of their first contract, several failed or died after using their signs for only a few months, but those months paid part of the cost of erection, and all signs were immediately installed elsewhere. Signs were put up on one-year contracts, current sold at rates averaging over ten cents per kilowatt-hour, and, to insure a proper use, a monthly minimum was required equal to about one and a half hours' daily burning. This

is not the only company that has worked for its share of the sign business. However, its experience is typical, and the plan succeeded because the promoters had faith in signs and made it easy for its customers to obtain them.

With a view to further increasing the sign business this same company has recently placed in operation a plan whereby the greater portion of its sign lighting will be entirely removed from its peak during the months when the peak must be considered. Free signs on a flat rate for certain stipulated hours each night is the nucleus of this plan. The time of switching on is placed about half an hour after the peak load. The turning on and off of signs is controlled by patrolmen, who not only attend to these duties but inspect all signs as well as solicit new business. It is expected that, as soon as this plan is under full headway, the increased business will necessitate the running of special sign circuits from the station. In this event the expense of patrolmen would be eliminated. Isolated signs at some distance from the main streets are controlled by time-switches.

The flat rates adopted are based upon current for the first two hours each night at regular rates and at a low rate for every hour's burning thereafter. Customers are thus induced to continue long-hour burning.

The meter has been a formidable obstacle in the upbuilding of the sign business. In most cities and towns the early closing movement is in vogue, and this makes the flat rate welcome, as many merchants are obliged to leave their signs and windows in darkness rather than go to the expense of employing a watchman to cut their lights out at a certain hour.

The flat rate has a particularly good effect on sign lighting, as it insures use of the sign six or even seven nights a week, while those operated on a meter basis are used only the nights when the store is open, which is the time when we already have large demands for our current.

Before the adoption of this flat-rate schedule it was argued that no customer would be willing to contract for a sign that could not be turned on during the first half-hour of darkness, but experience has proven that this question is waived in many instances, the specific rate overshadowing this point. To the customer who desires the other method the meter is always available. Again, this flat rate has been the means of stimulating a large amount of

sign business away from the heart of the retail district. It finds favor with the neighborhood stores and with business places on the back streets. Further, it has demonstrated the fact that an electric sign as an advertising medium is a pronounced stimulus to trade in the outlying districts.

If the flat rate is feasible for sign lighting, why not apply it to window lighting as well? As the hour of closing comes, the average merchant turns the key in the door and leaves his entire store in darkness, the very best advertising hours for his wares being thereby lost. If he could be assured of a specific rate per month for the lighting of his display, would not such a rate be an inducement to have lighted windows until ten, eleven or even twelve o'clock each night? Sunday window lighting could also be induced by this method. It is strange that so many merchants allow this, the best advertising day in the week, to slip by without taking advantage of it. On Sunday evenings, while waiting for cars or strolling for pleasure, people have more opportunity to inspect windows than at other times.

ILLUMINATED BILLBOARDS

By the large national advertisers, billboards and signboards are now classed with the newspapers and magazines as strong mediums for reaching the public purse. The latter can be read during both daylight and night hours, but not so the billboard. Its usefulness ceases as soon as the sun goes down. It is through the medium of the lighting companies of the country that these billboards can be made to tell their story by night as well as by day. In treating this subject in a general way I am fully aware that in a few metropolitan centres illuminated billboards are maintained to a limited extent.

Recently, in conversation with one of the members of a large eastern bill-posting company, I discovered a decided leaning toward the illuminated billboard. There is no question but that the National Bill-Posters' Association would welcome a plan whereby the efficiency of advertising space could be made more valuable. In the past they have fought rather shy of this matter, owing to the great difference in the lighting rates prevailing over the country. If there were some means whereby this association could meet the National Bill-Posters' Association on a fair footing, establishing a uniform lighting rate for the entire country (by

that I do not mean necessarily a low rate), I believe that it would be the means of producing a splendid volume of new business in which all lighting companies would eventually participate.

Advertising appropriations are usually distributed through advertising agencies. Experts plan the campaigns with the expectation of obtaining certain results. Various mediums are used, according to the product to be sold. For their services the bill-posting companies charge a specific amount per foot for painting, a specific amount for position, and a specific rate per sheet for posting. This rate is uniform throughout the United States. All of the details of illuminated billboards would fall upon the bill-posting company; maintenance, posting and collections. It would then only rest with the lighting companies to furnish current at a uniform rate.

For instance, should the American Cereal Company, manufacturers of Quaker Oats, desire to cover the state of Colorado with an illuminated billboard campaign, it would only be necessary to place the order with the Denver Bill-Posting Company for, say, 300 boards. They would be able to quote at once a specific price for this service, and could guarantee location, posting and illumination, knowing the prevailing rate for lighting.

I believe that this plan is worthy of consideration by this association. The advertiser is seeking novelties, he has the money to spend, and it only remains for the lighting companies to come forward with a plan to be able to secure their share of the advertising appropriations.

DISCUSSION

THE PRESIDENT: We have come West for information, and in declaring this subject open for discussion I think Denver might almost be said to lead in the amount of attention it has given to the development of new business, through usual and unusual advertising methods, and I would therefore ask Mr. John Craig Hammond, advertising manager of the Denver Gas and Electric Company, to kindly open this discussion on the general subject.

MR. HAMMOND: There are many different ways of advertising, as we all know. For example, if I were the press agent for the broncho-busting contest that was given this afternoon, I believe I should carry out the scheme that was suggested here

this evening to the effect that notice be given that the Humane Society had decided to swear out warrants for the men that conducted this broncho contest and for those who attended it, on the ground of cruelty to animals. I heard one of the men interested in this contest speaking about the possibility of arrest, and he was badly scared. Instead of being frightened, I should welcome it. I should like to see the sheriff come up and arrest the entire body—and he may come, too. The idea of that is plain to all. The public mind is of such a nature that every one in Denver would be glad to go to-morrow to see a contest that was claimed to be cruel. Unfortunately, I did not see the contest this afternoon, but Mr. Tuft, our humane agent, decided to arrest some people for carrying on the contest. I might say, for the comfort of any of those here who have "cold feet," that the mayor of Denver is present and maybe he will help them out if the officer does arrive. If the parties interested would carry out the idea of having this organization arrested for attending that contest, he would secure great publicity for his show and he would in that way secure advertising that could not be equaled by an expenditure of thousands of dollars.

That would do for a broncho-busting contest; for an electric-lighting company it would not do.

The Denver Gas and Electric Company has been one of the pioneers in the advertising of gas and electric appliances. We have an exhibit in the rear of the hall that tells its own story, to a certain extent. It does not wholly tell its own story, however, for there are a number of things in the exhibit that would be considered out of place by a man who did not know the local conditions. Not a piece of literature has been issued that has not had a theory or an idea back of it.

By the way, theory is sometimes a bad thing in advertising. Advertising is a matter of dollars and cents, as the men who pay the bills well understand. For instance, in our advertising campaign there was a street-car card issued that related to mormonism. When that card was put out the subject of mormonism was before the public in the daily press, and it was an opportune card. Advertising must be of a pertinent nature. I do not mean to say that a piece of advertising matter issued in Denver will not hold good in some other city, but, at the same time, local conditions govern to a great extent; there is no doubt about that.

I heard a man criticize a card. He said he could not read it. For instance, that transfer card—you from other cities, perhaps, would not fully appreciate that card. Here in Denver a person in the street car will recognize it at once; it is a *fac simile*, on a large scale, of the Denver City Tramway Company's transfer slip. The passengers on the car notice it; they see the flash line. We have a line of red at the top that arouses their curiosity. They read it. People have been heard to say that they stood on their heads to read it. It is a good "ad," in my opinion.

The subject of advertising is one that necessarily involves considerable generalization, but I believe that the advertising field is one of even greater importance to the plant than is the generating of more power. If you have a plant that will give satisfactory service and take care of the business in a general way, then I believe you should turn it into a commercial proposition. There is only one way in which to do this, in my opinion, and that is by advertising, which has become a science. Advertising is really in its infancy. There is not a man in the United States to-day who understands it thoroughly. We all have our own schemes, our own methods, and some men may have brilliant schemes, and some may not; but advertising of all kinds brings in certain results.

As it stands to-day, advertising in the electric field must be followed by solicitation—followed intelligently and persistently. Without the solicitor a great percentage of the advertising loses its value; the returns are reduced at an enormous rate. The soliciting department and advertising department must work hand in hand; each depends upon the other. This is the condition now.

The great point to-day—and what we are coming to in the advertising field—is self-supporting advertising; advertising that stands alone. This is a thing that I believe will come; and I am not a theorist, as I wish to impress upon you. I do not mean to say that we can do without solicitors. I mean that we are working toward a higher percentage of returns on the advertising direct. But if we can turn an electric-light plant into a commercial proposition and educate the people to use more electric current, we are making that property more valuable and increasing its earning power, and that is what we want to do. It is

simply with you all a proposition to sell more current; how are you going to do it?

There are different methods. I have my own ideas; here in Denver we carry them out. We are boastful on this one point—that we do not copy any other company. We originate and create. There has not been a piece of advertising matter sent out by the local company that has been copied from other companies. That is not necessarily a strong point in its favor, but we have shown results. The motto of Denver some time ago was "Forward." To-day it is "The City of Light." Mayor Speer, who is in this room, is in favor of "the city of light." The proposition was laid before him, he was told the idea and the suggestion, and it developed until to-day the people of the city are in favor of "the city of light."

I believe it is possible to educate the public to perceive that while it was dark, now it is light. The human mind is peculiar. You must know how to do it. That is good advertising. There is one great principle in advertising—you must have something that is legitimate; you must have a solid proposition. You can not bunco the public; you can not fool it; you can not get it to part with its money on the old theory of saying that John Smith was kicked in the head by a mule, had four teeth knocked out, took Dr. Chamberlain's cough syrup and was cured. That won't go to-day. You must have something legitimate—something that appeals to the public.

I should like to suggest to the president that the advertising business is such an extensive field—and I am sincere in thinking it is of vital importance to every central-station man—that we might continue this discussion to-morrow. Personally, I should be glad to answer any questions; I should be glad to prepare a paper if necessary. I think it is good for the game. I will be honest with you. I won't tell you all; I am going to keep some things up my sleeve, because that helps me; but for the good of the association I will try to answer any question that is asked.

The President: My idea was to take some further time to-morrow for the discussion of this subject if it is not closed to-night. I will give the members an opportunity of asking those participating in the discussion any question they desire. Will Mr. Gilchrist speak on the subject?

Mr. Gilchrist: Mr. Chairman and gentlemen—I have been looking over Mr. Hammond's display and the displays of the other companies that have sent advertising matter here, and I think it is a liberal education. It seems to me, after looking it over, that Denver is a very fitting place in which to discuss this matter of advertising and electric signs, because certainly Denver, in the matter of advertising done, the high character of it, and in the development of its electric-sign business, is far and away ahead of any of the cities in the United States that have come to my attention.

I believe that a certain amount of money can be wisely spent for advertising in connection with the business-getting department of every company. I have heard statements made by some central-station managers—generally in small cities, I will admit—something like this: "Our plant is there; the people all know where we are, and they know what we have to sell. What is the good of advertising? If they want light, let them come around and get it."

Even in a small community there is no doubt that advertising, although you can not trace the direct results at all times, will do good. The company that I represent started in, possibly five or six years ago, to do a little advertising. That has been increased each succeeding year. We are issuing a bulletin with the results of which we are entirely satisfied, and we feel that we are warranted in spending for advertising probably one-third of the entire amount that we spend in getting business. We have conducted during the past year an advertising campaign that was arranged for us by the Bates Advertising Company, of New York, and have watched the results of it very carefully. They prepared for us a lot of material that was very unique, and good in many ways. We have kept a closely-tabulated record of all the returns that we could trace directly to it, and the amount is very considerable. When we take the total cost of that campaign and figure the direct results, our cost per lamp—16-cp equivalent—obtained is high; but I have a theory, and I think it is sound, that you are warranted in spending a larger percentage for a certain excess of business that will be the direct result of advertising—business that otherwise you would not get—than you would be warranted in spending for your entire business. For instance, we will take the case

of a station that by the canvassing methods—which we will assume are thoroughly up to date and about as ample as the territory will permit—will bring in an increase of one hundred thousand 16-cp lamps equivalent per year, and we will suppose that it costs to get these lamps from twenty-five to thirty cents per lamp for the expense of your business-getting department. We will assume that the field has been worked to the absolute limit. Now, if the advertising man comes along and shows you where you can get an extra twenty-five thousand lamps in that year, even at a cost of one dollar per lamp, that you can not get in any other way except by advertising, I think you will all admit that you are warranted in spending that one dollar per lamp for the extra twenty-five thousand lamps, because in the development of our business time is very much of the essence. It is not to any man's credit or any company's credit to get an amount of business in a period of three years that might have been obtained in a period of one year; what shows to the credit of the central-station man is the amount of business he can get in the shortest time. Some stations will pride themselves on having in a year obtained fifty thousand lamps. Why not double their energies and get that fifty thousand lamps in six months? Suppose we do spend money; after all, it comes out of the other fellow. I am thoroughly in favor of spending a very considerable amount in advertising. The question of how much should be spent, as based on your gross sales, is the problem. I should estimate it to run somewhere from two to two and one-half per cent. That would include the entire costs of getting the business and the advertising; two-thirds on the soliciting force and one-third on advertising.

The President: Is there any representative from the Boston Edison Company who would like to discuss this paper?

Mr. Ingalls: I should like to ask Mr. Hammond, if it is not a personal question, about what percentage of his gross receipts is spent in this advertising campaign?

Mr. Hammond: I can not tell you that off-hand, Mr. Ingalls. I do not recall the amount. We are running on a month-to-month basis. I could not tell what the percentage for the present month is; I shall be glad to answer that question to-morrow.

Mr. Ingalls: I think that is a very interesting question,

because the larger companies are probably spending a much greater proportion of their receipts for advertising than are the smaller ones, and in our experience in New Jersey, where we have towns of from nearly 300,000 inhabitants down to 2000, we have adopted the same advertising methods straight through the entire state, using practically the same proportion of our receipts in the small towns that we use in the large towns; and the results obtained in the small places have been just as good as the results in the large ones.

MR. C. F. HEWITT (St. Joseph, Mo.): I ask Mr. Hammond if he can tell us about what percentage of increase in his gross receipts his advertising has obtained for him; the approximate average. I ask Mr. Gilchrist the same thing.

MR. HAMMOND: To answer that question would be a good deal like the statement of one of our employees. He said he had increased his business 100 per cent in a week. We asked him how it was, and he said he had sold one sign that week and had not sold any the week before. We make out a weekly report that shows the number of prospects we have at the beginning of the current week and the number at the end. Our prospects, for example, at the beginning of the week might be 1000, and at the end of the week 2000. That is on account of the representatives of the company covering the town and finding new prospects. We sold during the week ending May 20, last year, 156 appliances; during the corresponding week this year we sold 356. Our advertising appropriation was something like 12 per cent less than it was the year before. We show in some cases returns as high as sixty-three times the money spent. There is no one in this room who will doubt that it is absolutely phenomenal—sixty-three times returns on advertising! I have not heard of that being done before. I will confess that it was a virgin field to the extent that it had not been worked hard and was lying fallow. We went after it, and produced that result. On some classes of advertising we average perhaps 12 per cent in contracts closed. We have not fallen below 10 per cent in the last five years on any branch of our advertising.

MR. GILCHRIST: Mr. Chairman and gentlemen—It is almost impossible to give an answer to the question asked by Mr. Hewitt. I would cite as an illustration—to throw a little light on the matter—a point that is a small feature in our business,

but demonstrates the advantages to be derived from advertising. In the Bates campaign, of which I spoke, we had a number of lists. One of these lists was made up of the residence customers already on our lines, to whom we sent letters with the idea of encouraging them in the use of more electricity. We called their attention to a great many little devices in the way of portables, and current-consuming devices generally, and as the heating apparatus is of a class that appeals particularly to the householder and we could describe it in glowing terms, we paid considerable attention to that. We had done some advertising on that line, but very little, and the solicitors had paid very little attention to the sale of heating devices. In this advertising we named certain articles and gave plainly the prices at which they could be purchased, and the result has been that during the last three or four months, when we were advertising, as compared to the corresponding months last year, when we were not advertising, our sales of that kind of apparatus increased about 250 per cent.

We can, of course, trace a great deal of lighting and power business directly to advertising; but we must remember that there is a well-defined but indirect effect of the advertising on the minds of the prospective customers, of which the advertising does not get the direct credit, resulting in business that is brought in by the soliciting force; and when you have a large soliciting force on the one hand and a considerable amount of advertising going out on the other hand, it is a very difficult matter to make comparisons. I think if the conditions of general prosperity were exactly the same one year as another, and you advertised one year and did not advertise the next year, you might make an estimate on that basis; but we find these general conditions differing so from year to year that we are thrown out in our calculations. We are satisfied, however, from the little things that come up—like the matter of heating apparatus that I have described—to continue with our advertising.

Mr. Ingalls: It is probably very difficult to determine just what advertising and soliciting will do for a company. As Mr. Gilchrist has said, very few companies advertise one year and give it up the next. We had an experience in one of our towns last year where, owing to the fact that our plant was loaded up to the muzzle and we could not take any more business, we had

to give up advertising for a while.. We were under the impression that discharging most of our solicitors and giving up our advertising would not have a marked effect and that several months would elapse before we noticed any difference in the business that came in; but, as a matter of fact, almost the very day that the men were laid off and the advertising stopped the new business slowed up. It was only a week or two before we saw a very marked difference and we practically did no new business until we were in shape to take on more business and began soliciting and advertising. I think that illustrates very well the condition of the small town that does no advertising.

MR. R. W. ROLLINS (Hartford, Conn.): I ask Mr. Gilchrist if the bulletin issued by the Chicago Edison Company leads to any beneficial results.

MR. GILCHRIST: I can only say in answer to that question about the same that I did in answer to the other question. We know that our bulletin is thoroughly appreciated. As an illustration, I will say that one of our engineers, who is a very able man but sometimes does not get on to what is going on around the office until after it has happened, went out to figure with a man on the question of taking current. He made certain statements to the man and the man came back at him and said: "I have seen all that; I read it in your bulletin nearly two months ago," and this man went on to tell our engineer what else he saw in the bulletin. We find by little matters that we advertise in the way of specialties, which we change from time to time, which advertisements immediately raise a demand for these articles, that it does attract a good deal of attention. We issue most of the bulletins through drug stores—35,000 of the bulletins—and out of that number we rarely bring back more than five per cent. In many of the drug stores they will all be gone, and we replenish the stock several times during the month. The druggists tell us that they have many applications for the paper long before it is out; that the women and children, particularly, who come into the store will ask if the new *Electric City* is out, and they will bother the druggist until it does come out. We are getting applications from dozens of druggists asking us to send them copies of the paper for distribution.

MR. HAMMOND: I suggest one thing that will probably be new to Mr. Gilchrist. When I was in Chicago I had something

to do with a publication. The drug-store people would send in, and write letters, saying that the women and children were anxious to get this publication. We were led to believe that it was a raging success until one day we started an investigation and found that a large number of these requests from druggists for the paper were because they did not have any wrapping paper and they were using our publication for that purpose. Perhaps Mr. Gilchrist would do well to look into that matter.

MR. GILCHRIST: I should like to say, for the benefit of the gentleman, that no one would have the affrontery to do up drug-store materials in such a paper as *The Electric City*.

MR. LEE: In regard to new business methods, this spring, in a territory we had recently acquired and in which we put into effect our new business methods and soliciting, we created more new business in a month's time than was done during the entire year of 1904 by the company that had the property before we bought it. This was in New Jersey. Nearly all the gentlemen who have talked on the subject are representatives of the big companies—the companies that have the exhibit; but I believe that the central-station man in the small town, with a small appropriation, can get just as good results as the big companies with their large appropriations. If you have only $500 to spend, spread it out; do not spend it for one booklet and send that out and then throw up your hands. Get out five or six pieces of matter, and issue them two or three weeks apart. Follow up the matter thoroughly. I believe that any company can create new business in that way in towns of 10,000, 15,000 or 20,000, just as well as in cities like New York, Chicago, Boston and Denver.

MR. MCCABE: I desire to ask the gentleman from New Jersey what percentage of the gross income of the company he expends for advertising in a city of 10,000 inhabitants.

MR. LEE: It would be rather hard to make that estimate, because our plan of campaign is rather large. We are able to buy better designs and pay more money for them by having a large advertising campaign, covering a number of different towns, than could be done in a town of 10,000 inhabitants. I should say, however, that probably one-half of one per cent would cover it very nicely for advertising proper. That is, one-half of one per cent on the gross earnings. The large general advertisers—

like Wanamaker—figure on about two per cent of their gross receipts for their advertising, I believe.

THE PRESIDENT: Will Mr. Williams, of New York, speak on the subject?

MR. WILLIAMS: I do not know that anything can be added to this very interesting discussion on advertising and getting new business. We must not lose sight of the fact that all of our advertising should be largely supplemental to personal canvassing. Both should go hand in hand. Newspapers, street cars, bulletins, follow-up letters, postal cards—all of these things should be at all times so constructed and issued as to follow up most effectively the work of the canvassing department. Advertising is a branch of the canvassing department, and in my opinion one without the other is incomplete. I think, also, that it is very important to classify advertising matter carefully according to the business and to the men who are working in the different commercial branches. We have gone so far—perhaps too far—as to issue a series of letters of this separate order to each line of business we can reach. We send one kind of letter to the owner of a laundry, another kind to the owner of a butcher shop. We even solicit Chinese laundries. Chinamen are among the best customers that can be found. We are ourselves surprised oftentimes at the extent to which a very small shop-keeper can profitably use and pay for electric light; three or four times as much as has been paid for gas will be paid for electric light in one form or another.

I have been greatly impressed by two things in Denver—by a great many things, in fact, but especially by two things—the extent to which sign advertising has been developed, making the city far more beautiful at night than it could be without it—beautiful as the city is—and the extent to which sign advertising takes, not only the conventional forms with which we are all familiar, signs composed of letters and monograms and made up in panels, but outline work on cornices and around sign boards. I saw last night, in roaming about the city, a sign covering the entire side of a building, perhaps 60 feet high, completely outlined by incandescent lamps. I should like very much to hear from the local company, if practicable, of the details of furnishing signs and this outline work; the method of charging and the terms made with the public.

In line with some of the other companies, we are furnishing signs free in certain sections of the city. We do not attempt to control their use. We do say what the cost will be and guarantee the cost provided the current is used a certain time each day, one hour or two, as the case may be. The sign may be taken down as the arc lamp may be taken down, when it is no longer desired, and put in the store-room, awaiting another consumer. Our panel signs have the advantage that there is no abnormal depreciation. As the panel may be changed or repainted, the life is not dependent upon the occupant of the premises.

I think we have not touched upon the use of high-grade reflectors in show-windows elsewhere to the same extent that one finds them used in Denver. They seem to be of very high power, and from small initial candle-power to give a great deal of light at the bottom of the window, the lamps being concealed at the top. I have not seen anywhere so much high-grade window lighting—which is a form of advertising—as in this city, and I do not doubt that it would pay the companies to give special attention to the development of reflectors of high power for window lighting, exactly as they give special attention to sign work, motor work, or any other branch of their business.

The President: Before adjourning for the evening, I desire to refer briefly to a matter set forth in my address, namely, a suggestion made on behalf of the Association of Licensed Manufacturers of Incandescent Lamps, bearing on the subject of advertising. We will take up that general subject the first thing to-morrow morning, when we expect to hear from Mr. J. R. Crouse, who is chairman of the advertising committee of that association.

(The meeting then adjourned until Thursday morning.)

ORDER OF BUSINESS

THURSDAY, June 10, 1905.

FIFTH SESSION, 10.05 A. M.

1. Paper—"Co-operative Plan of Lamp Manufacturers for Business Promotion, with a Suggested Broader Plan." By J. ROBERT CROUSE
2. Report—Progress of Electric Heating. JAMES I. AYER, Reporter

SIXTH SESSION, 2.30 P. M.

1. *Wrinkles*—H. C. ABELL, Editor
2. Report—Committee on District Heating. W. H. BLOOD, JR., Chairman
3. Report—Purchased Electric Power in Factories. E. W. LLOYD, Reporter

EXECUTIVE SESSION

1. Report—Committee on Amendments to Constitution. HENRY L. DOHERTY, Chairman
2. Report—Committee on Nominations. LOUIS A. FERGUSON, Chairman
3. Election of Officers
4. Report—Committee on President's Address. LOUIS A. FERGUSON, Chairman
5. Report—Treasurer
6. Report—Committee on Rates and Costs. CHARLES L. EDGAR, Chairman
7. *Question Box*—HOMER E. NIESZ, Editor
8. Report—Municipal Ownership. ARTHUR WILLIAMS, Reporter
9. Report—Committee on Relations with Kindred Organizations. JAMES I. AYER, Chairman
10. Report—Executive Committee
11. Report—Committee on Standard Rules for Electrical Construction and Operation. CHARLES L. EDGAR, Chairman

FIFTH SESSION

The meeting was called to order at five minutes after ten by President Davis, who called upon Mr. J. Robert Crouse, of Cleveland, to open the discussion on advertising methods.

DISCUSSION ON ADVERTISING METHODS

Mr. Crouse: What I wish to present to this association is perhaps a little different from the papers that have been presented and discussed. As I am going to read only two pages from the paper that I have prepared—which is seventeen pages long—I will simply say that the proposition involves the co-operative publicity by the manufacturers of electrical apparatus and supplies, co-operating directly with middle men of all sorts; middle men being understood to include central stations, dealers and contractors. I undertake in this paper to justify the proposition that I present, which is done on pages 13 and 14 of the paper, which I will now read. The proposition would involve, if carried out as I suggest, the expenditure of about $287,000 by the manufacturers of apparatus and supplies. As one gentleman said, that sounds well, and is a good thing if it works.

Mr. Crouse read the following paper:

CO-OPERATIVE PLAN OF LAMP MANUFACTURERS FOR BUSINESS PROMOTION, WITH A SUGGESTED BROADER PLAN

The Association of Licensed Manufacturers of Incandescent Lamps, acting favorably on the recommendation of its advertising committee, has appropriated the sum of $10,000 for the purpose of effectively co-operating with the central lighting stations of the country for the increased use, and in consequence sale, of incandescent lamps.

Our present plans contemplate its expenditure in two ways:

First—To be helpful in stimulating central stations along advertising and new business lines, which have been so ably treated in your past conventions.

Second—To assume the cost of the preparation of an effective and comprehensive plan of advertising and soliciting, which in consequence could be furnished by some central bureau or advertising agency at a very low cost.

The above hastily sketched plan lacks completeness in one thing, for which this fund was insufficient; namely, an advertising campaign in a carefully selected list of periodicals and magazines reaching the wealthy and the well-to-do, emphasizing by facts and illustrations the many advantages of electric lighting.

We ask your association to appoint a committee of three of your members, representing central stations respectively in cities of approximately 10,000, 100,000 and 500,000 population, or over, with whom we may discuss our plans in detail and advise from time to time.

One idea, in conclusion, which the insufficiency of our appropriation has forced upon our attention:

This $10,000 appropriated by the lamp interests of the country represents a trifle less than one-fifth of one per cent of the annual lamp sales, and we believe the results will fully justify the outlay. A gain of one per cent over the natural growth of the business would call for 400,000 lamps.

This means for the other manufacturers, as a result of your

co-operation with us, more boilers, engines, generators, transformers, switchboards, and so forth.

A vigorous and carefully conducted campaign of advertising in a carefully selected list of periodicals and magazines, which we contemplated and believe would bring good returns, is more of a proposition than the lamp manufacturers alone could reasonably be expected to carry. It is a proposition, however, that is easily within reach of the electrical industries generally at a reasonable cost through co-operation.

The sales of electrical apparatus and supplies in 1904, exclusive of telephones and telegraph apparatus and supplies, were conservatively placed at $143,500,000. If a corresponding appropriation of one-fifth of one per cent should be made on this amount by the various electrical manufacturers, it would make a business generator and "booster" with a potential energy of $287,000. Such a fund, handled through what might be called a bureau of electrical information, we believe would render it possible, through suitable publications by means of explanations and illustrations of generating apparatus and devices, to make a matter of common knowledge and desire the many applications of electricity, from curling irons to electric locomotives.

To reduce this proposition to simple terms, an increase of 1.34 per cent in volume over the natural growth of the business would mean about $1,913,333. If this added volume were to yield a profit of 15 per cent, it would cover the appropriation of $287,000.

We believe this scheme is not impossible of accomplishment and that it is charged with tremendous possibilities for increasing the business.

We, as manufacturers of incandescent lamps, having considered the subject in a small way, should be pleased to co-operate with a committee from your association for its further consideration and for conferences with other manufacturers.

MR. CROUSE: That, I think, gives the gist of the paper. I have undertaken to present, so far as possible, the feasibility of working out the scheme. If this interests the manufacturers on one hand, as calling for a considerable appropriation, and on the other hand will serve the central stations, I consider the paper will have served its purpose. I have suggested, in the conclusion

of the paper, that any one who can give ideas along this line be good enough to communicate with me. It is my purpose to take this up further with the manufacturers of electrical apparatus and supplies, to see what can be done with the idea.

I may say that the lamp manufacturers have contributed a fund of $10,000 for a similar purpose, to co-operate with the central stations to introduce the use of incandescent lamps more largely. If the other manufacturers of electrical apparatus will come up with the coin as well as the lamp manufacturers have done, it will create the fund that is the title of my paper.

THE PRESIDENT: In regard to the suggestions made by Mr. Crouse, it is more than likely that when the report of the committee on the president's address comes before us action may be taken looking to the appointment by the new president of a committee to work on the lines suggested by Mr. Crouse. We all appreciate more and more the necessity of advertising to increase our business. It seems to me that it is one of the most practical subjects with which we have to deal and is of great and growing importance.

I have been asked to draw the line in the discussion this morning, if I can, so that it may relate to experiences in advertising for new business in places from about 7000 to 15,000 population. I mean by that, plants that are not connected with any large company, but are operated separately in cities of about the populations mentioned. If there is any gentleman here who has had any experience in advertising and other business-getting methods applying to plants of that size, I should like to have him address the meeting.

MR. L. E. WATSON (Kearney, Neb.): I am a representative of one of the small lighting plants, and, like the gentleman from New Jersey—I believe it was—who said he had used advertising methods until he was able to load up the plant, as he expressed it, clear to the muzzle, I want to get at the best means of advertising small plants. My advertising methods have been small, but rather unique in the way I went at them. I was up against a very stiff competition with the gas plant, and had taken charge of a rather run-down electric-light plant. I made personal solicitation of a majority of the business people of the town, and directed personal letters to them. Another scheme was, on par-

ticular days—such as holidays, particularly on New Year's day—to send a letter to each one of our customers and prospective customers, the letter properly dated, and addressed—to Mrs. John Smith, we will say—having the appearance of a wedding invitation, or something of the kind, gotten up as neatly as possible, setting forth some little thing that we had put forward in connection with our business.

One thing, which I think brought us more business than anything else, was the decoration of my office with ferns and other plants. As you all know, it is an impossible thing to raise plants indoors where they burn gas of the average quality produced in the small cities. The average housewife, and the average woman, is a great lover of such things, and I was able by cutting out all gas from the offices to have a beautiful display of ferns and other plants. That attracted a great deal of attention, and in a very short time I had very beneficial results from it.

MR. L. W. EMERICK (Fulton, N. Y.): Whatever problems we may have in our business, we have one in common, and that is getting new business. Primarily, that is my reason for being here, and I hope to profit by the experience of other people along this line. I am interested in the subject the president mentioned—getting business for small plants in towns of 12,000 to 15,000 population. I listened with close attention to the gentlemen who spoke here so entertainingly and authoritatively last night, but could not help feeling that one feature of the problem was not touched on at length, and that is the small plant.

For the sake of an example, we will assume that I have a plant in a town of 15,000 inhabitants, a good modern plant, our service of 24 hours and of good quality; there is a field, but we can not get all the business we ought to have. Business comes in slowly and steadily, but not so fast as we want it or so fast as it should come in. I think I speak for others in the same class, that we should appreciate some suggestions from those who speak with authority, from experience, as to what lines we should follow to get this business. We are necessarily limited in funds in many cases, and it would not be possible to spend as large a percentage of our gross earnings as was mentioned last night. Advertising in a small way costs relatively more than it does on a large scale. I should appreciate the value of any suggestions as to what lines should be followed; personal canvassing, newspaper advertising,

circulars, letters, and other ways. Such work as I have done has been taken from the busy hours of my other duties, but no regular advertising campaign has been conducted, through lack of time. It has been intermittent, and with indifferent results. We are in such shape now, however, that we can give some time and money to the question of advertising.

MR. R. E. ALLEN (Walla Walla, Wash.): The question of getting new business has been one of paramount importance in our locality, inasmuch as we have just completed a plant that has a capacity three times the demand of the community. When the plant was bought last year by the present company, the electric part of it was heavily overloaded and the only avenue for business was through the gas department. I made a campaign through the newspapers for two reasons; one was that I wanted the friendship of the newspapers in the community, and the other was that I could better reach in that way the people who would be particularly interested. I started out by taking a full page in each paper each week, and after two months' advertising our gross output had increased 40 per cent over that of the same month of the year before. This year our output, since the first of January, in the gas department has been not less than 55 per cent more than during any month of the same period last year.

I have particularly directed my attention to the matter of small motor business. There are no manufacturing interests in the town, consequently we can get no large power business; but I have through suggestion, which I think influences a great many people, secured all the power business in the town with the exception of four plants—two breweries, one planing mill, which has to use steam in order to dispose of its refuse, and a laundry.

I had a peculiar experience a few days ago with the Oregon Railway and Navigation Company, who had dug a well and placed an order for a gasolene engine and pump. I learned of this after the order had been placed, and wrote to the general superintendent of the road in Portland, outlining what could be done with electric power. He referred the letter to his assistant, who telegraphed me to know if I could meet him at the train and explain the advantages of electric power over gasolene, if any. I met the assistant superintendent, and after talking with him influenced him to cancel his order for the gasolene engine and pump

and to place an order with us for an electric motor. A few days after that I received a telephone message from the agent of Fairbanks, Morse and Company, in Portland, asking what I meant by knocking them out of the business. They said, "We had this order." I answered, "No doubt that is disappointing to you, Mr. Parker, but we need the money and we can not afford to let a gasolene man come in with gasolene engines while we have this surplus power." I sold a small motor and gave them a flat rate of $60 per horse-power per year, which I consider was good business.

I think there is one thing that has great influence on small power customers in small towns, and that is telling them what their neighbors are doing. As you know, in small places everybody knows what everybody else is doing. When I see a prospective customer I make it a point to give him a list of the present users of power and the results they are obtaining every day, and I have found that except in very few cases the manufacturer can be influenced toward electric power. He sees some one else using electric power, and he finds out what they are paying for it. He finds that his neighbor is using the power and getting good results at small cost, and you then have very little trouble in securing his order for a motor.

MR. JAMES I. AYER (Boston): This discussion on advertising has brought to my mind a good deal of experience that has come to me in the course of my contact with central stations and through reports from central stations that have undertaken advertising campaigns that were not successful, and in all my recollections of such cases I think the causes of failure were evident. If the newspaper work brought unsatisfactory results, it was due to the fact that in their enthusiasm they jumped in and took a large amount of space. They started without any definite plan of campaign. They thought they would try the field and see what it produced. It is ill-advised to undertake newspaper advertising in that way; it is not worth while to spend money on printer's ink unless you are sure you are going to be able to follow it up. In handling advertising of that character, you should plan out a campaign for a period of not less than a year. The method of placing the advertising in your local papers should be seriously considered, and you should be careful to see that there is fresh reading matter in every issue, if possible. It is a difficult

thing for a busy station man to attend personally to the details of advertising and do it well. The trade papers and bulletins of the large companies are available, and out of the bulletins you can find sufficient matter, which you can clip, to keep your advertisements in the local papers fresh, and this keeps the public mind active and directed to your business with very little effort. You can in a short time lay out two months' advertising from a half dozen issues of such papers as I have mentioned. The average station manager is too much occupied with the other duties of his position to be able to give the amount of time that is really necessary to the matter of advertising except in some such manner as suggested.

One of the gentlemen referred to the matter of making your office an advertising room. That is well exemplified here in Denver, but, on a relatively small scale, it may be done in every community where there is a lighting plant. It is perfectly practicable, and certainly worth the rent, for you to occupy a store or location that is as good as that of any merchant in town. If it is not perhaps as important as some of them, it should be central, and you can make it very attractive by using the products and materials that suggest themselves for your advertising campaign. Attractive methods of showing up the office by electricity at night is a strong advertising feature. The office should be easy to get into; it should be on the street level; and if only a small office you should display there the stepping stones to the business, such as sewing-machine motors, portables, and so forth. To a great extent it is perfectly possible for every station manager to do these two things, and there is no doubt but that if you will be conservative and plan out an idea for your newspaper advertising, as suggested, you will find it wonderfully remunerative.

There is no doubt in the world that if you spend two or three hundred dollars in three months in a town of 10,000 people in newspaper advertising—or even half of it—you will be disappointed with your results and will give it up. That is the usual result. The goods that are to be displayed in connection with your office should be arranged in such a manner as to present the best display possible and also keep the articles in salable condition. All small samples, such as portables, fan motors, heating apparatus, and so forth, should be kept, if practicable, under

glass. If they are kept in a show-case they will be protected and will be presentable. When customers are shown goods and conclude to try something, you should deliver the article that you show them; in other words, even if you carry a stock of goods, it is better to give them the sample and take the article out of stock for your show-case. It keeps your samples fresh and your exhibition in good shape.

For central stations where soliciting must be done by the manager or by his assistant, these two methods are the ways to get business, the ways you will find most productive. I think it is pretty well understood that where you have samples you can afford to put out any of your samples to almost any of your customers on a week or ten days' trial. I do not think there is any doubt in the minds of most men as to its being not only desirable, but the best way to do; the way that will bring quickest and best results. All gas men are united in agreeing with that statement and such central-station men as have consistently carried out the practice have found it very profitable.

Mr. O. P. Sells (Grand Island, Neb.): The advertising question is perhaps of as much, if not more, interest to the property that I am looking after as any other, and for these reasons: Situated in a little town of 10,000 people there is electric and gas competition and the question of municipal ownership. There is one daily newspaper, which is favorable to municipal ownership, so we are shut out from newspaper advertising. Our community is not the class of people to take to folders and circular letters, and it has been quite a question with me as to what was the best way to reach the people. I have always been in the technical side of the business and not in the advertising side of it; therefore it is a study for me. The property has never paid any dividends until the last six months. We have installed new units for additional capacity, and, on the lines of the discussion last evening, the question with us is to load the new units as quickly as possible and get returns from that expenditure. I should like to hear from anyone who has had experience in that line—advertising in small towns, getting new business in a short space of time. I am sure such a discussion will be of interest, not only to me, but to a number of others who are similarly situated.

Mr. F. W. Willcox (Harrison, N. J.): I think the associa-

tion is to be congratulated upon the interest that has been shown in the subject of advertising. To my mind, there is nothing of more importance to electric-light companies, outside the question of rates. The question of rates and the question of advertising are the most important things that have to do with the success of electric lighting. I think the question divides itself into two parts: first, the conviction on the part of central-station companies as to the value of advertising, and, second, the undertaking of the work. I think it shows considerable progress in the matter when we find that the companies are convinced to-day that advertising pays. There was a time when few companies agreed that it was profitable to advertise. That time is past. As to undertaking the work, I think that if a vote were taken at this meeting, it would be surprising to find how few companies do systematic advertising—how few companies do any advertising at all. A few companies do it in a systematic manner; some companies do it irregularly; but a large number of companies do nothing at all. The reason in the latter case is that they have no means of undertaking the work. The members come to the meetings and become enthusiastic about advertising: they go home, and for various reasons the subject goes without attention and the matter is dropped. That leads me to indorse the project that Mr. Crouse has presented to you, which will give every central station the expert advice and assistance necessary to conduct this work. I shall be disappointed if the plan does not meet with the hearty indorsement of a majority of stations, particularly small stations.

It is surprising how little electric light, relatively, is used throughout the country to-day. That fact was brought home to our company by the sale of a little decorative outfit for Christmas lighting. We were surprised to be told in Boston by the firm of Schwartz Brothers, toy dealers, that where they had one inquiry for the electric outfit from people who had electric current in their homes, they had fifty inquiries where they were asked if the outfit could not be used on some kind of battery. I have been impatient at the delay in extending the service of electric light and power, and while much of it has to do with apparatus, more has to do with the lack of progressive methods in pushing the business. I hope the idea of Mr. Crouse will receive the full indorsement of the members of the association. If the lamp

manufacturers can show you how to make two lamps burn where only one is burned now, you should have no objection to indorsing the plan and giving them the additional business that such work will bring about.

THE PRESIDENT: We should be glad to hear from Mr. Martin on this subject.

MR. MARTIN: Mr. President, this subject of advertising was referred to briefly in my report on progress, and it was in preparing that report, and in making some inquiries of lighting companies, that the fact was brought home to me that the subject of advertising was being neglected in a disastrous manner by local companies throughout the country. I thereupon determined that it might be interesting and valuable to the members of the association if I brought together a small exhibit of advertising material and methods. That exhibit you have seen at the end of the room. Had more time been given to it, a better display would have been made; but I am so much encouraged that I should like to see it repeated on a larger and fuller scale at our next meeting, when I believe it would not only be a good thing to have the members at the convention study the exhibit carefully, but, in whatever city we happen to meet, to invite the general public to view the exhibit. I believe the immediate effect would be a visible percentage of increase in the business of the local company in that city, as well as in the expansion and amplification of the advertising methods pursued to get business throughout the country.

The subject of advertising shows itself in so many aspects, Mr. President, that it is impossible to expatiate upon them all. Mr. Ingalls' paper is an admirable exposition and summary of the conditions of advertising and its relationship to the business, and I want to take this opportunity of expressing my commendation, modestly—certainly my admiration—of the work that has been done by the advertising men of some eight or ten of the leading local companies of this country. I think the work of such experts as Mr. Ingalls, and other men in similar positions, is unsurpassed, and I doubt if it is equaled, in any other line in the introduction of a special article throughout the country. But it is not possible for very many of the lighting companies to command the services of such highly-paid experts—and when I say highly paid, of course I do not speak from their own standpoint. I

noticed that Mr. Hammond last night, in his very pithy and pertinent remarks, gave himself a little boost by saying that all his work was original, was created by himself, that he found no necessity for imitation in any quarter. While there are not many John Craig Hammonds, there are also not many companies that can afford to employ the work of such experts.

The suggestion has, however, been offered by Mr. Crouse of a method by which the companies may secure such expert assistance, and he has put the plan in very practical form and has brought it to you in the shape of a donation of $10,000, which would help to popularize and render general the methods that have already been adopted by these eight or ten leading illuminating companies. Ten thousand dollars expended in advertising is a mere drop in the bucket. I believe a million dollars could easily be spent this year in advertising electricity throughout this country, and the results would show next year. But, as Mr. Ayer has stated, it does not do to bunch your expenditure; you want to spread it out, and as we who are in this electrical business are in it to stay, we might as well lay out a campaign that will be good, not merely for this year, but for next year and the coming ten years. The time is ripe. It is the psychological moment to interest the public in what you are doing. This is shown by the interest in the question of municipal ownership, for example. We have a wave of that sweeping over the country at the present time. I do not think there is much feeling or intensity in the idea, but it is more or less in the nature of a hypnotic suggestion. One town sees another moving in the matter; one newspaper editor sees another editor writing on the subject, and it is taken up and pushed along.

Advertising itself is suggestion. I think you want to take up that idea and fill yourself as much as possible with the knowledge of the value of suggestion—advertising—in getting your business; but do not expect too much of advertising. Use all the other methods commonly in vogue. For example, one of the leading companies in this country, the concern that issued the pioneer bulletin—I mean the New York Edison Company—does probably as good work as any company in this country, in any field, in intelligent, persistent and successful advertising, but it does not depend merely on advertising by bulletins, circulars or dodgers, nor on advertising in the newspapers and magazines. It has a

follow-up system; and in this album, which I fortunately have with me, I have a series of letters addressed to me as a man who is indifferent to electricity, and they want to get my business. The whole campaign is developed in this album, which I should like some of you to read, that you may see how cleverly the idea is followed up until I am landed as a good, steady, large consumer of current.

The $10,000 to which I have just referred is not for the benefit of the large companies, at all. It would cut no figure in their advertising appropriations. It would cut no figure in the advertising appropriation of any one of them; but the companies about which our president spoke, those that are located in cities of ten, fifteen and twenty-five thousand people, can derive a great deal of benefit from the judicious expenditure of this money. I do not think a single local company here should flatter itself that it is going to get an appropriation out of this fund and use that for local newspaper advertising. By all means, advertise in the newspapers. Keep close to them. Advertise in them whether they are praising your business or condemning it; if they condemn it, they are advertising you anyhow. They are not doing the harm you may imagine, because the public has a capacity for reasoning out things for itself, and where enmity may be developed by too sharp criticism, friendship will also come. Newspaper advertising is not merely that of paid announcements. I presume there is not a central-station company out of the 4000 in this country that does not have happen from week to week some interesting event in connection with its business, some story, and, knowing as I do the newspaper men in the country, I believe there is not an intelligent reporter or editor who would not welcome the opportunity of getting that story into his columns. It is news for him and advertising for you, and won't cost you a cent.

Now, as to the practical methods of spending part of this money, if it should be determined by you gentlemen to accept it. I do not know how far this association cares to commit itself in accepting money from the manufacturers. That is a serious proposition in many respects, but I believe this appropriation comes without strings and with the best of motives; unquestionably a selfish motive back of it, because in spending money in advertising you will help the manufacturers to get rid of more of their

product. One of the best ways that occurs to me in which to apply that money for the benefit of the small companies is to have a committee created, which committee would have associated with it one or two experts; then, possibly, to get up some handsome albums, like this one of the New York Edison Company—perhaps a hundred of them, costing from $25 to $50 apiece—and insert in each album samples of advertising done in newspapers, circulars and dodgers, follow-up letters, and all other methods of advertising, including the artistic material such as that used by the New York Edison Company and the Boston Edison Company. Circulate these albums from company to company, letting each of the member companies of this association have the benefit of inspecting one of them. If that is done once or twice a year, every member company in the country will get the benefit of the best work that every other member company is doing; and I think the whole art and the exploitation of the best means of selling current—light, heat and power, whatever it may be—will be benefited.

There is also one other idea. This association has issued from time to time admirable bulletins devoted to lists of prices charged for current for light, heat and power, and also bulletins devoted to rates obtained for municipal lighting. I think it would be a good idea if a canvass were made of the companies in the association and a bulletin were issued giving the details of the work done by each of the 500 or 600 companies in the association, so that in that way also, they could compare their methods and derive ideas and suggestions from what other companies are doing.

MR. RUSSELL: I want to try to answer some of the questions asked by the gentleman from Nebraska. The company with which I am connected is in a town of 15,000 inhabitants—Massillon, Ohio—and we are up against a proposition of thirty-cent natural gas. Now, if there are any more members in the same trouble, I should like to know it.

THE PRESIDENT: Will those gentlemen that are in a similar situation raise their hands?

(Two members raised their hands.)

MR. RUSSELL: I have been with this company only about two years, and when I began I did not know an arc lamp from an incandescent lamp, you might say, but I found there was not

a cent spent for advertising. We have two daily papers in the town, and I took six inches at first and ran an advertisement in one paper on Wednesday and in the other paper on Saturday; that cost me 48 cents an insertion. Then I learned from some of the bulletins, or from *Illustrated Electricity*, or from Mr. Martin's paper of last year, that it was policy to send out letters, and I began doing that. These were so effective that it was only a few days ago that a man told me if I did not quit writing letters to his wife he would break my neck; but I am going to make a customer out of that man and his wife. About this time there appeared the little periodical called *Illustrated Electricity*. I have not any connection with it, but we take fifty copies of it every month. We have a card system, and these copies go out every month to persons who are on our list; that card system is looked over frequently, and as fast as we get a customer the card is removed. In this town of 15,000 inhabitants we have set it down as a rule that we must get ten new customers every month; and we get them.

Now, about this natural gas—it is a hard proposition; but in these days when everybody is preaching hygiene, sanitation and cleanliness, that is one of the ways in which you can get at them. We talk to the housewife about house-cleaning time, and we ask if she has looked at her curtains and decorations, the varnish on the piano, and all that sort of thing. The first thing you know, the man who has a little house, say six or seven rooms, which he has built and decorated very nicely—at the end of the first year his wife comes around to him and says: "John, we thought we had our house pretty nicely papered, but we have got to have that ceiling cleaned." As soon as I hear that, either my superintendent or myself is right after that fellow; and these are the people that we are winning away from natural gas.

In our advertisements we keep ever before the people the price, as Mr. Willcox suggested; because in a town of that size they think in dimes, whereas in cities like Denver, New York and Boston, they think in dollars, and the man in the small town wants to know how much it is going to cost. One form of our advertising is to tell a man how often he winks in daylight, in gaslight, in candle light, and in electric light; because the wink is the sign of eye weariness, and if you will look it up you will find that in electric light you wink only about 1.8

times a minute. Lately, I have used a scheme gotten up in New York for an advertisement, and it is headed in big letters "DO IT NOW," and under that you can use as much space as you want. I confine myself to about four inches, but I keep everlastingly at it. That is the way we are going to get customers.

In regard to our show-room, we have a 20-foot office, with a window in it, and we keep it just as bright as we possibly can all night long and work the plant scheme that the gentleman from Nebraska suggested. Any of the central-station managers in these small towns can write letters, and you can make eight carbon letters as easily as one on the typewriter, and if you will send out fifty or one hundred of these every month, and keep at it, you are bound to get business.

Mr. Gardiner (Boston): I gather that we all believe in reasonable advertising, and the problem that we are wrestling with now is how, when, where, and to what extent. I was very much interested last evening in the statement that the Chicago Edison Company's advertising campaign had been laid out by the Bates Advertising Company, of New York. I want to ask a question: Assuming an advertising appropriation of from $5000 up to $50,000 or $75,000 per annum, is it better for a public service corporation to lay out its advertising campaign in its own office, in view of local conditions, or to place the matter in the hands of some advertising concern, such as the Bates Advertising Company? It seems to me that there is a question of policy; that is a serious question, greatly affecting the efficiency of the returns.

I have recently been going over the items of a very considerable advertising campaign. It fell under four major heads: newspapers; programmes, theatre and otherwise; street-car advertising, and bill posters or display signs, paper and paint. Some of the advertising agents discouraged me very much on the bill-posting work, except as a follow-up form of advertising. They pointed to the fact that general advertisers throughout the country who use bill posters and paint work use it as a follow-up method to their newspaper and magazine advertising. It had appealed to me in exactly the reverse way.

Another method is street-car advertising. I have heard very little here about street-car advertising. The question arose as to whether or not we should advertise in the street cars, and

it was decided that we should not advertise in them during the present season, but would possibly take it up in September and transfer our bill-board appropriation expended during the summer-time to street-car advertising expended during the winter-time.

In connection with bill-board advertising, certain questions arise. What is the best way to place the money? In comparatively large areas on paper, on what I call transient boards—that is, boards on car routes, that are passed by electric cars—or put the same amount of money into comparatively smaller spaces at central points, in paint? Is it better to have a large number of boards in ordinary places, or a small number of dominant boards? Personally, I believe in the central location, painted boards, supplemented to a considerable extent by paper boards; but I believe in every painted board being the dominant board in a central location. For instance, the other day I engaged a board 12 feet by 65 feet, painted, opposite the largest transfer station in Boston. At that point a matter of some two hundred thousand people are transferred each day. I think that money is much better spent than an equal amount of money spent in boards scattered throughout the city—paper boards. I should like very much to hear from the prominent advertising experts here on the relative use of these different mediums. We have heard that they believe in the monthly pamphlet, in which I thoroughly agree.

There is another means of advertising, which I have not heard mentioned, and that is the use of a company button by all the representatives of the company. The Edison company in Boston, I know, has a very neat and attractive button, which is used by all special representatives, meter readers, and so forth, and that focuses the eye on the advertising of the company if it is used in conjunction with the company's general advertising. I have here a button—which perhaps is not quite alone in this convention—that is used by all the gas companies in Boston; by their meter readers, bill deliverers, special representatives, and others. The special representatives use the button in a smaller size, a lapel button, and the meter readers have a similar design on the front of their caps. That button has been mentioned as a strong point in advertising. The gas companies propose to run this trade-mark, a registered trade-mark, in connection with

their advertising, and make the different forms of presentation of gas mesh in and fit in together; so that when a consumer sees a meter reader with this button on the front of his cap he immediately thinks of some large display advertising that he has seen elsewhere, advertising gas for heat or for cooking, or advertising some special apparatus. It seems to me that is a good line of advertising.

There is another question that I should like to ask, and that is if in display advertising or newspaper advertising, street-car advertising also, it is better to generalize or to individualize. For instance, in a street-car advertisement, let us say that we show the Edison company's button insignia, "Edison Light," and around it simply the words "Light, Cooking, Heat, Power." These are the four main fields of use of electricity. There is no amplification of any kind. That covers practically the entire field, and in a concise, imperative way, which will be, I think, read by every one who sees it. As against that form of presentation in all methods of advertising is it not better in one advertisement to tell the story of lighting as concisely as possible, but in an educational way, saying more than simply "Light by Electricity?" The matter could be changed in other advertisements to cover cooking, various kinds of cooking by electricity, and in other advertisements the use of electricity for heat and power could be described.

Mr. Gilchrist: My judgment would be that much better results could be obtained by being specific and not trying to cover the whole field. People generally are not interested in the statement that the company is offering to sell electricity for light, heat and power. They will pass it by without notice, but if you will advertise some special feature to which electric light is peculiarly adaptable, or an illustration of the application of electric power to some use that is quite common, through the medium of a picture that has artistic merit, the advertisement will attract attention on account of its artistic qualities, even though the person may not be particularly interested in the electrical features of it. The advertisement might illustrate the use of some heating or cooking appliance.

I have been very much interested in and have appreciated the force of some advertising that has been done in the Chicago papers by the People's Gas Light and Coke Company, who run the gas interests in that city. They have been running quarter-

page advertisements, with a very well executed picture of a woman using a gas stove. In another of their advertisements they have an illustration of a gas engine running, showing the shafting connected, and it is certainly very strong advertising. It has attracted a great deal of attention and it has led me to the conclusion, through all the comments I have heard upon it, that that form of advertising is very strong. In regard, also, to some of Mr. Hammond's newspaper advertising in which he works in local color, his cartooning of the prominent men of Denver, I can very readily see how a campaign of that kind would attract widespread attention.

MR. LEE: The presentation of this matter has interested me deeply. I should say, in regard to advertising electricity, that it would be better to specialize all kinds, forms and uses of electricity. In regard to signs, I believe every central-station man should have an electric sign put up over his office, because you are advertising electricity and you ought to set the pace for the merchants of your city. There are a number of good signs on the market, changeable and otherwise. Make constant changes in your signs. It is one of the very best means of advertising for the electric-light company itself to use these signs to show the merchants how it can be done. Then you can get out after them for business. As the basis of your advertising campaign, I believe the newspapers should be considered first. Then come the follow-up methods; personal solicitation, followed in a general way by booklets, street-car cards, and so forth.

MR. INGALLS: I am sorry that this discussion can not go on longer. I wish that some effort might be made at the meeting next year to give the commercial men a chance to say all they want to say and to hear all they want to hear on this subject. I believe it would be of just as much importance to lighting companies to have these matters thoroughly gone over as it is to listen to technical discussions.

In closing the discussion on advertising methods, I will mention that there are several things that have been touched upon but lightly. One is the question of show-rooms and display-windows. These are really very important and are within the reach of everybody. Almost every merchant can buy a small amount of apparatus for a display-window. A great many of the manufacturing companies would be very glad to help the central-

station companies by giving them some of their stuff to display, so as to encourage the use of the apparatus. I suppose the demands that would be made on a company like the General Electric Company, if they went into the distribution of samples, would be something enormous. But there are many things that will interest your customers that can be had on six months' consignment and displayed in your ware-rooms.

The preparation of your lists used in follow-up or other advertising campaigns is really of paramount importance. It really does not make much difference what kind of advertisement you send out if you send it to some one who could not possibly be interested in it. If the companies undertaking advertising would expend the proper amount of time in preparing their lists, seeing that there is no dead wood there and that all the people on the list are likely to be interested in the subject advertised, they would get a great deal better results. It is infinitely better to have a small, live, growing list than a great big dead one into which you will throw a great deal of money and will waste both your time and your money.

I think that the statement made to me yesterday by one of the representatives of a large eastern company was very much to the point. He said: "These fellows out West certainly are hustlers. There is one thing that has impressed me very much here. Every man I have met here who has on a yellow ribbon (the badge of the entertainment committee) has tried to do something for me. I am going home, and the first day I get back I am going down the line, and if I have any man in my employ who is not paying the greatest possible attention to the public, he is going to get out right away. I am going to clean shop and see that my men are fully impressed with the importance of treating the public properly."

Mr. John Finney, of Denver, a member of the American Institute of Electrical Engineers, addressed the meeting, urging the members of the association to attend the annual meeting of the institute, to be held at Asheville, N. C., June 19 to 23.

THE PRESIDENT: We will now take up the report on the progress of electric heating, by Mr. James I. Ayer, of Boston.

Mr. Ayer read the following report:

REPORT ON PROGRESS OF ELECTRIC HEATING

Your reporter is able to say that there has been a steady increase in the extension of electric heating in the past year which is at a materially greater rate of growth than in the preceding year.

With the thought that expressions from the members of the association indicating their experience and methods pursued would be of the most value touching this subject, a set of questions was mailed to all central-station members. As may be expected in such cases, all returns were not as complete as could be wished, but many of them, and a number above the average in such cases, show a lively interest in the subject developed by their appreciation of this application of electricity. The answers were as follows:

Total number of inquiries sent out....................	480
Number of replies received..........................	235
Number with heating apparatus on their lines........	112
Number without heating apparatus on their lines.....	119
Number of blank replies....	4

Replies from the 119 without apparatus on their lines:

Operating gas plant, 6. No day circuit, 16. Can not compete with natural gas, 7. Interested and intend pushing the coming year, 19. Make no remarks, 69. (Most of these have no day service.)

Question No. 1—Do you sell electric heating apparatus to your customers?, Answer: 93—yes; 19—no.

Question No. 2—Do you sell at retail or at cost? Answer: 61 sell at cost, 16 at small profit, and 16 at retail.

Question No. 3—Do you keep a record of heating apparatus on your lines? Answer: 59—yes; 53—no.

Question No. 4—How do you learn of new additions? Answer: from meter books; inspection; through supply dealers; permits for additions; customers' reports.

Question No. 5—Do you make special rates for electric heating for residences? Answer: 24—yes; 88—no.

Question No. 6—State lighting rates and conditions under which you make heating rates. Answer: highest, 20 cents per kilowatt-hour; lowest, 5 cents per kilowatt-hour; average, 12.5 cents per kilowatt-hour.

Question No. 7—What heating rates do you make for stores and factories? Answer: highest, 20 cents per kilowatt-hour; lowest, 1.33 cents per kilowatt-hour; average, 9 cents per kilowatt-hour.

Question No. 8—What is your experience as to the advantages derived from the electric heating business?

The following are most of the replies to this question in full:

1 Not very good.

2 Can not compete with gas.

3 Such that we want all we can get.

4 Increased revenue, and consumers get more for their money.

5 Sells current at a profitable rate, a great advertiser, and secures other connected load.

6 Increase of day load.

7 We believe only in electric heating as applied to cooking, curling-iron heaters, irons, *et cætera*, but not for radiators, having found that too expensive.

8 It is just beginning to be appreciated.

9 Flat irons sell day load at 3.33 cents special rate, which is very profitable to any plant having water-power. Our source of power is water exclusively. Minimum charge on cooking circuit, $3.00 per month.

10 Heating can be placed on same basis as power and has same load characteristics.

11 It's growing; it is good for day load.

12 Slight, except as an accommodation to customers.

13 It increases our revenue without any material additional expense.

14 Popularizes the use of electricity by demonstrating its adaptability for other uses than lighting, and tends to "level up the valley" in the load curve.

15 Just the same as so much more lighting.

16 It gets the customer in the way of thinking that he may apply electricity to his comfort and convenience in various ways.

17 Experience limited to a few heaters and irons. Possibly the whole capacity does not exceed 5 kilowatts.

18 That it is a profitable addition to the business of a plant desiring a day load.

19 So far, we have found no heating apparatus that was satisfactory. The cost of operation too high and apparatus constantly out of service.

20 Experience limited, but what we have is good business.

21 Consider it a good day load.

22 Mostly day load—at time other users are not drawing current. Attracts lighting and power business.

23 It is a good thing in every way. We consider it a good advertisement for our business.

24 We believe that electric heating will become a very important part of our business in time.

25 Small appliances popularize electric current.

26 We want all we can get.

27 Not yet in a position to say definitely from experience, but shall be within six months from date.

28 Think that it is a business that should be pushed.

29 Its greatest advantage is as an additional convenience; an inducement to residents to use electricity for lighting.

30 It certainly increases our income, but the apparatus installed so far has no appreciable effect on our day load.

31 Flat-irons for small residences a big success.

32 We believe in it, not because we have enough to affect our revenues largely, but because its convenience makes it a necessity when once installed and so has a tendency to bring and hold customers who might otherwise use gas.

33 Have had but little yet. Are out for more and believe that branch should be pushed.

34 Small appliances are all right.

35 It might interfere with developing our gas business.

36 Very satisfactory for small apparatus, such as irons, curling-tongs heaters, small disc heaters, stew pans, chafing dishes, soldering irons, coffee pots, warming pads, *et cætera.*

37 The present heating load, while by no means large, is mainly a day load, and therefore a desirable one. The advantages of electric heating appliances, however, appeal to the general public in such a way as to advance electric energy and popularize its use.

38 We believe the people who have used small current heating devices are pleased with the convenience and cleanliness of them and that there is some income. We are, however, not able

to say what it amounts to in proportion to our other business. The demand for apparatus seems to be growing.

39 Have but a small amount of heating apparatus out. Apparatus is difficult to sell; even at cost prices it is too high for our customers.

40 Good profit to company; customers find it expensive except in special cases where convenience is of more importance than cost.

41 Are all right if you can get the customer to pay the increased cost over gas heat.

Question No. 9—What method have you pursued to extend the use of electric heating? Answer: 64—advertise and solicit; 48—made no effort.

Question No. 10—What method seems most effective in getting results? Answer: 16—personal solicitation; 13—free trial of apparatus; 13—demonstration and advertising with bills; 70—no opinion.

Question No. 11—Have you secured any laundry, clothing factory, or similar operating plants using any quantity of flatirons? Answer: 37—yes; 75—no.

Question No. 12—What are the net results to your customers as to cost of operation and results as compared with previous methods of heating? Answer: 18—more expensive, but customers better satisfied; 14—cheaper and better than old method; 4—very expensive; 76—no answer.

Question No. 13—What previous method of heating was used? Answer: 18—gas; 11—gasoline, coal and charcoal; 15—gas, coal, wood, charcoal, oil and coke; 68—no reply.

Question No. 14—Do you supply current for heating in other industrial establishments, and to what extent? Answer: 15—yes; 97—no.

The following are most of the replies to this question in full:

1 Laundry and pantaloon factories can not use electricity. Irons will not give sufficient heat to use satisfactorily. The dampness from garments is the cause. We have experimented and failed.

2 Customers seem to prefer electric heating because of the cleanliness.

3 Our progress has been hampered by a municipal ownership campaign of three years' duration.

4 Think heating units are a great thing and will be a big factor in the light and power business in a few years. Where the consumption is small you can not absorb meter losses and fixed charges. The beauty of the thing is in the fact that much of the heating consumption is in day load.

5 We find the demand steadily increasing for electricity for heating purposes, not only for factory but also in the way of domestic appliances.

6 If the first cost of heating apparatus could be reduced materially it would be taken up by a greater number of customers and made one of the every-day necessities about the house.

7 We have forty kitchens fully equipped and using current exclusively for cooking, all giving satisfaction. Every outfit put out on trial; only two equipments out of 42 returned. Three hundred flat-irons put out on trial in private residences; only 25 returned. We find that heating of irons and cooking apparatus at our rates (3.33 cents per kw-hour) is satisfactory and feasible, but that air heating of rooms is not. . . . Electricity can not compete with the other methods of air heating.

8 We hope to make a drive in the near future.

9 We have in some cases agreed to install heating apparatus, payment to be made if the same proved to be satisfactory in every way, cost of operation to be included. In every case the apparatus has been retained, and we think it is a good policy in some cases.

10 The first cost of apparatus is too high to secure general adoption, but we expect to extend business considerably during the coming year.

11 Our heating business is too small to be of any value in making general comparisons. Flat-irons are practically the only heating we can do.

12 Our principal business thus far has been with private residences. We have two department stores having restaurants using electric heating apparatus, and one small hotel.

13 We think it desirable to push heating pads, laundry irons, *et cætera,* and other devices for domestic use among our residence customers, for two reasons—First, a desirable day load that helps remove the objection to paying the minimum charges in summer. Second, it affords another strong tie to hold our customers and aid in getting new business.

14 The current we supply for heating is confined solely to small apparatus.

15 A little ashamed to add that our experience is so limited it is of little value. Hope to do better for next year.

16 A lady, very much interested in domestic science, advises me that after using an electric oven for a period she finds it extremely satisfactory and believes it approaches, more nearly than any other kind of oven, the famous brick oven of our grandmother.

17 We are working up a fair day load on heating apparatus. We show all kinds of heating apparatus at the office of the company to our customers, and supply same if the customer can not get supply dealers to do so promptly.

18 Notice we make a residence rating on about 40 per cent of the total lights installed and will not add the heating apparatus to the rating. We are considering a power rate for cooking, but have not yet decided what it will be.

19 We operate and own gas plants in connection with our electric plants and prefer encouraging the use of gas.

20 We intend to look into this matter more thoroughly in the future and if there is any chance to get heating or cooking business enough to pay, will make a rate of 5 cents or less for this class of service.

The questions seem to have shown the following:

That about one-third have no heating apparatus on their lines, mostly those who have no day service. With those who have, there is a growing interest. Generally sell apparatus at or about cost. About one-half keep such a record as they may from sales, inspection permits, meter records, *et cætera.*

That a comparatively small per cent make special rates (21 per cent of those reporting).

With a few, there is a strong impression that the cost for service is high and a serious handicap. With others, that this does not apply to many useful devices, that the introduction of heating goods is important as broadening the field of usefulness of electric service among existing customers, and where rates can be made sufficiently low, material additions in day loads develop.

That the best methods of extending the use is by office exhibits and demonstrations, loaning articles for trial, and personal solicitations.

That there are some material loads of a desirable character added from service to laundries, clothing factories, and other

industrial establishments in fifty-two cases; that those customers found the service more satisfactory, though in some cases at a higher cost for heat than by other methods.

That the cost of apparatus was a factor in limiting the sale.

Your reporter feels that this last point should receive attention.

The average critic does not always appreciate that an electrically heated tool or device is materially different in its make-up from its fellow of older acquaintance. Aside from producing a device as like as possible to the one it displaces, it must contain a heat generator made to withstand use and abuse in unskilled hands while operating at high temperature, thus calling for great care in design, construction and selection of material. Of the number made compared with articles of like character in common use they are as one to many thousands. The cost of selling is also quite high as compared with articles better known and of wider application, because the field, generally, is restricted to those using electricity who may be persuaded to discard some familiar well-known method and device and buy the new.

These are the principal reasons for what is considered high cost of electric heaters.

Some few stations report failures in efforts to successfully introduce apparatus under conditions where others succeed. This is generally due to the lack of a proper understanding of requirements, methods and apparatus.

While it seems a simple matter to substitute an electric iron for a gas iron with equal or better results, and it can generally be done, yet there are kinds of work, kinds of operators, and kinds of irons differing in their individual characteristics which must harmonize when properly combined; all of which means that a thorough acquaintance with the devices you are introducing is essential.

As to cost of operation, I feel that a word should be said.

There are favorable conditions where electric lighting is cheaper than gas, unit for unit, where you may not have to include compensating advantages to equal an unfavorable difference in first cost, but you do not find the extension of business possible under such conditions only. On the contrary, you have taught the public that a better thing is worth more, and they know it.

The electric heater in many of its forms comes to you as a

compensating advantage to-day to assist in further extending that belief by supplying a service that in some cases can not be obtained by any other means at any price. It meets many household demands better, and usually more cheaply, than they can be met by any other means. With the many household, shop and office conveniences available, the electric heater is, except for long continued service, a medium more attractive, convenient, safe and sanitary than any other, and can be operated cheaply enough to furnish an additional reason for taking on or maintaining electric service from a central station.

Your reporter desires to thank the members who promptly responded to the questions sent out by the secretary for this report.

Respectfully submitted,

JAMES I. AYER, Reporter.

DISCUSSION

MR. MCCABE: Is it possible to know the cost of domestic coal in the town referred to in answer No. 7?

MR. AYER: The cost of fuel is very high.

MR. EARL WHEELER PAUL (Ontario, Cal.): I sent in that answer—No. 7. Coal is $12 a ton and gasolene 19 or 20 cents a gallon. We have no gas at all; we use either wood, coal or gasolene. The gasolene is very explosive and coal is out of the question, and we made this cheap rate of 3.33 cents.

MR. MCCABE: Could you not have got a better rate?

MR. PAUL: I do not believe so. The 3.33 is about on a par with gasolene.

MR. A. L. SELIG (Los Angeles, Cal.): Our company has been paying considerable attention to this branch of the business for some time, but we have not done it systematically. A year ago we had on our system possibly a dozen flatirons in residences. About that time we began a campaign for the introduction of the flatiron as a necessity rather than as a luxury, with the result that we have on the system to-day more than 600 irons, consuming possibly 75 to 90 cents each; and in our case, being a water-power company, adding absolutely nothing to the expense except office expenses. We have introduced these irons in laundries, supplying about eight laundries, the installation varying from fifteen to fifty irons. We have displaced gas irons in a town where gas is sold at 90 cents per

1000 cubic feet, upon a basis of three cents for electricity. We find that three cents for electricity in an ordinary flatiron is equivalent to gas at about $1.00 per 1000, and our experience has taught us that laundries and families, or anyone else having to do with that particular apparatus, will pay from 10 to 25 per cent more for convenience, quickness and cleanliness in the use of electricity as against ironing by any other method.

We have also—and I regret to say that I have not had time to tabulate the results of this particular investigation—for a year past been experimenting with complete kitchen outfits in one of our towns, selling the current for this particular outfit at four cents per kilowatt-hour, with the distinct understanding that the family was to keep a daily record of what they cooked, how long it took to do it, and to read the meter before and after each piece of work; so this, I take it, will be a somewhat valuable record for this association to have when the results of the experiment are tabulated. We find that the particular family that was given this advantage for the purpose set forth is satisfied with the result and will continue to use this apparatus as against gas that can be bought at $1.50 per 1000 cubic feet.

The question was raised by one of the local companies as to the possible utility of electricity in laundries in ironing. It seems to me that the experience of that company must have been particularly unfortunate, because this question has not been raised in any of the laundries on our system. We have been supplying some of these laundries now for about a year and, as stated, they prefer electricity to any other method of doing their work; in fact, two or three of them are now equipping their mangles with electrical devices, cutting out gas for that particular use, and on a three-cent-per-kilowatt basis.

We have endeavored to introduce electricity for heating space, but find that to be a failure. You can not do that except in isolated instances, where persons have a very nice house and are able to pay the bills. In our country the conditions are peculiarly adapted to the use of electricty for heating if it were feasible. We have cool mornings and evenings in the winter, and it is warmer during the day, so that the use of electricity for heating would be limited and the expense necessarily small in comparison with other sections of the country where they have more rigorous climates; but in our section of the country, except

in isolated cases, such as the residences of wealthy people, the use of electricity for heating space is a failure; and we discourage rather than encourage it, because we have found, in a dozen instances, probably, that persons who would like to have the convenience of heating space by electricity have bought the apparatus without our knowledge and installed it, and then simply gone up into the air because of the amount of the bills. Instead of doing us good, it does us harm. It is possible if you have a long purse to indulge yourself in the luxury of electric heating, but if you can not afford to pay the bills do not heat with electricity.

We find that electric irons, electric culinary apparatus, curling irons, and these small things, which pay anywhere from 25 to 50 cents or $1.00 a month to the central-station company, can be successfully introduced, but can be pushed only by personal solicitation. We engaged a woman who knew the advantages of the apparatus, and she told us she would go upon our system (we are in a city where there are three competing companies, but she said she would confine her work to our lines) and would sell these irons for us upon a margin if we would let her have them at cost. We did that gladly, and she introduced a number of these irons for us. We let a lot of them out on a 30-day trial and out of the hundreds put out 65 per cent stuck, and we believe that our revenue this year from this kind of service will be increased not less than $10,000 a year without appreciable expense to us.

Mr. P. H. Korst (Janesville, Wis.): This electric-heating business has been of much aid to us in one respect. We have had considerable difficulty in holding our small residence customers, owing to the minimum charge we have had, in common with most lighting companies, of $1.00 per month. They find that during the summer months they use but 40 cents worth of current and we charge them $1.00, and they do not feel good about it. We lose some of these small consumers every year during the summer. We have taken up and pushed the electric laundry iron for domestic use, and we tell customers they can use it in summer-time practically without expense, since it enables them to use all the current that they pay for under the minimum clause. It catches them, and by means of the laundry iron we are enabled to hold their business and get the additional revenue the iron brings in during the winter months.

Mr. Julian B. Downey (Rawlins, Wyo.): Have you two meters, or are the irons on flat rate?

Mr. Korst: In the large installations we put on a separate meter and give regular power rates, but in residences they go on the regular lighting meter. You equalize the bills, because it is in the summer-time that the irons are used.

Mr. Downey: You get more than three cents, putting it on the lighting bills?

Mr. Selig: Yes, in families. I spoke of laundries, and giving that rate they agree to pay a minimum bill of 50 cents a month. My maximum rate is 15 cents and the average rate per family is about 11 cents.

Mr. Ayer: In connection with laundry work, I will say that there are upward of 600 laundries equipped with electric-roll heaters throughout the country. The laundry installations are growing. The question of the use of air heaters is like the question of the use of cooking apparatus on lighting rates. It is not practicable at the average lighting rates to do general cooking and take over all of it. It is not practicable to do cooking at a much higher rate than three cents, where you are going to do all the cooking; but you can utilize in your kitchen a broiler, waffle iron, coffee pot for the dinner table, a chafing dish, and similar things used from once a week to once a day, without any appreciable additional cost in the month's bill. I know of three cases, of which we have obtained data, where all the broiling in a family of from four to six persons, and the coffee-making, together with the incidental use of an occasional stove for toasting and doing little things in the evening, the use of the chafing dish, the use of the family flatiron—not for the laundry, but for use about the house; the pressing a woman does in dressmaking and little things that do not come under the regular laundry work—and in each of these three cases in no instance has the increase in the bill averaged more than $1.25 per month, or about 20 per cent increase over the lighting bill, where this free use of current was made.

A broiler requires 10 or 15 amperes at 110 volts, which is in service about 20 minutes; a coffee machine requires 200 or 300 watts for 20 minutes. The incidental use of the chafing dish is not large. The household flatiron is used in many houses from 10 to 15 minutes at a time, at most, for pressing a seam, or some similar service, and it is not necessary to keep it in service more

than ten minutes at a time. While the iron may use 400 or 500 watts, the total watt-hour use in a day is small and the service is cheap and convenient.

In regard to radiators, there is a field for radiators in dwellings that is very large and is becoming more so, and that is the use of radiators in the bathroom in winter; there is a demand for something to take the chill off the bathroom. It takes a 2000-watt heater to be effective and fifteen or twenty minutes to accomplish the desired result. When I give that rating of heater, I am speaking of the average bathroom and the amount of heat required to warm a room within the limit of time a man is willing to wait before the furnace in the house has got in its work. In practice, we have found that in seaside summer homes and in winter residences the radiator is a great success. It may cost seven, eight or ten cents, or possibly twelve cents, for the heat required to take a morning bath. Take that in the case of a man who wants the convenience, and the cost is low. It is a field that is growing larger every day, and a thoroughly practicable one. The experience of one of our members who installed an electric heater was not all just as expected. He was very much delighted with the heater, but he took a bath one morning just as he was about to go away on a two weeks' trip, and when he came back his bill was $96. He was the president of the company, which was an element in the case that made the situation a little easier to bear.

Mr. Selig: The idea of using a radiator for house-heating is absurd; it is the equivalent of something like $60 a ton for coal, under the best conditions.

Mr. Dunham: We have had two prominent cases in which we have installed electric heaters with pronounced success. We designed an oven for baking bread for a large hotel, and this oven has been in use for a year in making pastry, rolls, and everything of that kind. In designing the oven we put in a large amount of porous fire-brick. All the heat that goes into the oven goes in between half after four and six o'clock in the morning, and we charge two cents for the current. The experiment has been very successful. The bread is much praised. They had a gas oven before, but the proprietor finds the use of electricity to be a great improvement.

The other case is the heating of eight guest rooms in the

same hotel. The heaters are regulated from outside the room. When the proprietor lets a room he turns on the heat, and when the room is vacated he turns it off, when the heat is no longer necessary. The proprietor is afraid to have gas stoves in rooms occupied by guests. He is going to put six more heaters in bathrooms that are not easily reached by the general heating system of the hotel.

Another installation is in a large orphan asylum. The babies' room is so far away that they had to run the steam pipe 200 feet. In the summer-time they have a little heat in the room in the morning and evening. We charge them three cents.

MR. WILLIAMS: I think the association is to be congratulated upon receiving this paper and the paper on a similar subject presented last year by Mr. Ayer. We find that electric heating is a subject that is attracting public interest to an almost phenomenal extent, and of all our advertising material none receives such wide circulation as that upon electric heating. I have in my hand the advertising album of the New York company, and before me a heating circular, the first edition of which was 100,000 copies, and it has been necessary to duplicate it several times to meet the calls of the public—not arising from our side, but from the side of the public—on this subject. The point of the circular was to illustrate the various devices that had been put on the market; their probable cost; the cost of installation for the smaller devices, also the cost of running them by the hour. For example, a chafing dish costs to purchasers $11 to $21.50; to use for fifteen minutes, 1.8 cents—a rate figured on the highest New York lighting schedules. A waffle iron costs to purchase from $7.50 to $18; to use for fifteen minutes, 3.5 cents—that means for the entire breakfast period. A small flatiron may be purchased for $5.00; to use it for fifteen minutes costs three-quarters of a cent. The costs of use, when analyzed in that way, become practically insignificant.

I do not think that as a rule any of this incidental apparatus affects the household bill. In advertising recently our people adopted the method of writing to our customers and asking them if they had any of the following devices on their installation, then enumerating over 100 different articles. Even the electrical people were astonished at the extent to which electric current for heating is now applied to these various devices.

We advertise electric heating by circular and follow-up letters, by exhibitions in our various office windows, and more recently we have engaged a cook who goes from office to office, staying in each a month, who makes various things, such as waffles, small biscuits and chocolate, all of which is served to the public free. This has been a popular form of advertising, to say the least.

MR. McCABE: At the last meeting of the Ohio Electric Light Association Mr. Hillman read a paper on electric heating devices and stated that the cost of cooking by electricity for a family of five, at five cents a kilowatt-hour, would be $6.00 a month. That was in his family at Schenectady, and covered a period of six months. If Mr. Hillman is present, I am sure he could give us some interesting information on this subject.

MR. H. W. HILLMAN (Schenectady, N. Y.): My experience has now reached a period of about twenty months—nearly two years. I have had a bill from the Schenectady Illuminating Company every month on the regular schedule of issuing bills at a five-cent rate. I have kept these bills and have watched them carefully. For electric cooking and baking, with the use of the iron, some miscellaneous dining-room work, such as the use of chafing dish, coffee percolator, *et cætera,* and occasional use of the air heater in the bathroom and den, my average monthly bill has been $6.00. When the spring season approached the bill would increase perhaps to $8.00 or $8.50, never higher than $9.00. I account for that from the fact that the air heater was used more frequently. I am sure the average bill for electric cooking and baking and the use of the iron is about $6.00 per month. As time goes on, and with greater efficiency and interchangeable devices, the sum can easily be brought down to $4.50 or $5.00 at a five-cent rate. The conditions are a family of five, including a servant. The latter is a Polish girl of ordinary intelligence, who has been with us four or five years and is much pleased with this method of equipment in the kitchen and who gets along with it very nicely.

I might also say that my experience has covered all kinds of devices, all the different makes. I have changed ovens, broilers and griddle-cake cookers from time to time, so that what I am giving is conservative. I believe that later the cost can be brought down.

particularly about the girl's room; had it well lighted, well heated, plenty of windows, cool in summer and warm in winter. We gave very particular attention to that point. Following that out, it is much more convenient for a girl to get up in the morning, say at seven o'clock, and turn on a flatiron that will be heated in five minutes, than to get up at half after five and go down-stairs and build a fire. I am still, in my present house, subject to the building of a coal-range fire on Monday morning for washing; but in the new house that I mention I am arranging for heating units in the boiler, because servants absolutely insist upon boiling the clothes. They wash easier. With that arrangement the girl will go down-stairs at seven o'clock instead of half after five, turn on the heat for the boiler heater instead of making up the laundry fire; and I think that with Monday and Tuesday taken care of, and the conveniences of the kitchen outfit, it goes a long way toward retaining a good servant.

MR. WILLIAMS: I should like to know the kind of apparatus that Mr. Hillman has for heating his house. It would be a great mistake at this time, under present circumstances, to advocate the heating of buildings, judging from our own experiences. Much harm would come to the heating industry as a whole by any initial mistake on the part of the companies in urging electric heating for general use in place of coal or steam. The heating of a small office by gas, which is more expensive than steam or hot air, costs at a rate of slightly over five cents a kilowatt-hour, only one-quarter what electric heating would cost.

We have a heating engineer who devotes his entire time to the subject, and he has no trouble whatever in having electric heating adapted successfully in the mechanical arts where heat quantity and heat intensity are wanted. In printing and other manufacturing arts, there is nothing to compare with the electric current; but we have never yet failed to give electric heating and electric cooking a black eye where we have assumed its use in the heating of buildings. Any company starting out to get the larger business of heating buildings injures itself and, for the time, the electric heating and cooking industry.

MR. HILLMAN: I do not mean to advocate the heating of buildings. I agree with you in every way; but I do think the time is ripe for every central-station manager in this room to put an electric air heater in his house and see what it will do and what it will cost.

MR. GILCHRIST: I will cite one instance in line with Mr. Williams' talk. A director of our company has an estate just outside the city of Chicago. It is in the nature of a lodge, can hardly be called a house; it has six or seven rooms. He came to us to investigate the subject of electric heating, having previously had some talk with the people who manufactured the apparatus. In spite of what we could say to him, he insisted in putting a dozen radiators in the house. Everything went well until last January, when he had a bill of $178, net, and he earned a rate on our Wright demand power system of about 3.4 cents. He insisted that he had not at any time been able to keep the temperature of the house more than 12 degrees above the outside temperature. There was no one in the house but the servants, and the apparatus had been run for 24 hours a day.

MR. GARDINER: In emphasizing the remarks of Mr. Williams, I will say that two years ago in Boston we had a critical coal situation, due primarily to the coal strike in Pennsylvania, and then to certain teamster complications in Boston. The offices of the gas companies were daily besieged by people asking if we could not heat their houses with gas and heat their boilers with gas, saying they would do anything—go to any expense—to heat with gas; they literally could not get coal, in many instances. One gas company, for instance, had an involuntary increase of 40 per cent over the corresponding day of the preceding year, due to the demand made upon it by the public in small heating appliances. The gas companies invariably said, "No, you can not heat your building with gas." I do not mean to say you can not use a little radiator; you can do that more economically than you can run a furnace; but you can not have the bulk of your heating done with gas.

It seems to me, in view of that condition, that it is extremely rash to advocate any air heating, or heating a hot-water system, by electricity. I refer to having the hot-water heater in the basement, we will say; the water heated by electricity and the heat then distributed by hot-water circulation. I think it is rash to allow the public to think that there is any possibility of that. It simply creates discontent and trouble for the electric companies. The gas company has taken that attitude, and the electric companies should very much more do so.

MR. C. R. MAUNSELL (Topeka, Kan.): I have been intensely

interested in this discussion on electric heating utensils, but it seems to me there is one field that has not been referred to; that is steam heating for air heating of the house. We are throwing away about 85 per cent of our heat in exhaust steam. If that is applied for air heating, and the utensils here spoken of are heated by electricity for convenience and comfort, I think we can develop a large field in such a combination.

MR. H. C. ABELL (New York city): With coal at $4.00 per ton, you get 70,000 B. t. u. for one cent. With gas at $1.00 per 1000 cubic feet you get 6500 B. t. u. for one cent. With electric current at five cents per kilowatt-hour, you get 680 B. t. u. for one cent; at an efficiency of 100 per cent in each case.

MR. AYER: In all that I have said to-day I have tried to point out the idea of the members using the electric-heating appliances of the smaller class to strengthen their hold upon their customers. The thing a person finds useful and valuable is the thing you want to put into his hands. If a person gets a water boiler, or a little device of any kind, a flatiron, or any of the heating appliances, in his home, you have not only increased the usefulness of your current supply, but you are doing missionary work in educating your customers to a further use of electric current. But to advocate that you go home and make attempts to secure a wholesale application of electric heating is not my intention. In the first place, when you come to installing kitchen outfits, when you go into the larger application of these things, you must be informed about the goods you are putting out; you must know the goods themselves, must have had experience with them. This is not a thing that you will learn in a day. It is not difficult to learn about the simple things; nevertheless, it is the simple things that you must master by closer acquaintance with them before you will be in a position to put them out to the general public who will have no appreciation of the principles involved in heating methods. They do not appreciate the value of intimate contact with these appliances, and the host of little lessons to be learned.

In the paper I read on this subject last year I gave definite detailed data, and gave you advice, which I shall not repeat now, but it was to the effect that you should install in your own houses the apparatus with which you can and will do business in the future.

As to the cost of general cooking, you can safely figure that the cost for electricity must be down to three cents per kilowatt-hour to be on a par with good dollar gas. The calorific value of gas varies some, the efficiency of the devices in which it is used varies, and all that; but the record from a large mass of data shows that to be an average upon which you can count. With two families using the same kind of gas stove, where there is the same character of living and the same number of people, there will be a variation in the bills. The factor of the personal equation comes in, in the methods of handling the apparatus. But there is a law of averages, and the statement that it will take a kilowatt per person per day to do all the cooking for three meals for a family, will be found to be a safe average for a family of three persons and upward. It will not vary much with the increased size of the family; about 333 watts per meal per person. That involves a regular dinner, cooked by a servant in the regular way; not in the hands of experts or of people who are checking.

As to the wiring of a house, it is a simple matter to take care of the kitchen installation by running a separate pair of mains, which do not need to be large, from the main entrance wires of the house to the kitchen. It does not need to be very expensive. The allowance of current for the average family of four to six persons varies, but it should be at least 35 amperes, on 110 volts. That is the maximum demand likely to occur in any kitchen.

Where people want hot water they can secure an ordinary type of kitchen boiler, varying in capacity from 35 to 40 gallons, with a heater of maximum capacity not exceeding 2500 watts; they can install the electric heater and use it with good success. What is required for the bath in a small way is not a very heavy expense. The boiler should be located, and is frequently put in the water main, right in series with the kitchen boiler. In other cases, where it is wanted for the bath alone, a five-gallon or ten-gallon boiler is put on the water main in the bathroom. An hour's run at about two kilowatts will give a sufficient quantity of hot water for an ordinary bath, about 30 gallons. It is a question of rates as to whether you want to encourage that practice or not. Where you sell current at five cents, people will be glad to pay ten cents for a bath. Where

you attempt to heat water in the kitchen and utilize it as hot water is generally used, for dish-washing, *et cætera,* with the large incidental waste, it is impracticable; although some people do these things in that way.

I have in mind a dozen stations where they have installed hot-water boilers for cleaning lamp globes, and where a careful check has been made it has been found that the average supply of current to the boiler is about 500 watts per hour through the day.

In the paper presented last year I gave you some tables that tell how many watts it will take to get a definite amount of water heated to a definite temperature. This matter of water heating and air heating is very interesting; but it is mighty important how you tackle the work. But as to the smaller appliances there is no question, and I suggest that you get a stock of these appliances and push them. They will push you into more business and compel you to learn more about the general subject.

(The meeting adjourned until half after two o'clock.)

SIXTH SESSION

President Davis called the meeting to order at half after two o'clock.

THE PRESIDENT: The first business will be the presentation of *Wrinkles*, by Mr. H. C. Abell, of New York city. I thank Mr. Abell, personally, and I believe all the members of the association will join with me, for the satisfactory manner in which his duties have been discharged and the report prepared. As the report is printed and our time limited, I do not believe it will be necessary to read the report in full. We should be glad to hear from Mr. Abell.

MR. ABELL: As the president has said, the report being printed, I do not think it necessary to read it. I should like, however, Mr. President and gentlemen, to say a word with regard to the meaning of the word "wrinkle." Wrinkle, a curious or ingenious notion or device, a bit of useful information, *et cætera*, is derived from the verb "wring," to squeeze or press out by twisting or force. As it was a question whether or not I could apply the root of the noun that might have produced more wrinkles on paper, I submit the results obtained by less forceful means.

I will not take the valuable time of the association in reading what has been printed, but will merely mention two or three points. You will notice that I have included some rules and regulations—Wrinkle A 2. This was included as a bit of useful information for members to add to or take from, giving ideas to those desirous of drawing up rules for employees. Wrinkle C 14 should have been included in Section *F*, as it refers to boilers, and not in Section *C*, referring to lines, transformers, and so forth.

I take great pleasure in thanking the members of the association and the assistant secretary, who so kindly contributed to and assisted in the compilation of the publication I submit.

THE PRESIDENT: Mr. Abell's report is accepted with the thanks of the association.

(*Wrinkles* will be found complete in Volume II of the Proceedings.)

THE PRESIDENT: The next business will be the report of the committee on district heating, Mr. W. H. Blood, Jr., of Seattle, chairman.

Mr. Blood read the following report:

REPORT OF THE COMMITTEE ON DISTRICT HEATING

MR. PRESIDENT AND GENTLEMEN:

Your Committee on District Heating begs to submit the following report. The statements made therein are based largely upon data previously collected for the association and upon the personal observations and experiences of the members of the committee in operating district heating plants.

Your committee has resorted to this method of procedure partly because of the non-success experienced by previous committees in response to their requests for precise information on this subject from the managers of various companies engaged in the steam-heating business, and partly in view of the fact that the heating season in some localities does not end until May, which would not allow sufficient time to tabulate information for the current year.

To every electric light manager the following questions at some time or other present themselves:

First—Is district heating profitable?

Second—What conditions must be taken into consideration in determining whether or not it should be undertaken in my particular locality?

In the report of last year's committee we find that, of the companies answering the questions submitted, 84 per cent stated that "from all points of view their investment in the heating business was a good thing," and that 16 per cent were not satisfied with this business; and on the assumption therefore that district heating is profitable under certain conditions we have prepared this report.

We submit (1) some points that should be taken into consideration when contemplating the installation of a district heating plant; (2) a few suggestions as to how this portion of the business should be managed; (3) an attempt at a comparison of rates, and (4) a set of rules relative to customers' installations.

(1) CONSIDERATIONS RELATIVE TO THE INSTALLATION OF A DISTRICT HEATING PLANT

External Conditions

Nearly all the old Edison plants, and in fact all direct-current plants, are located near enough to the centre of distribution to warrant district heating. For a central station which is a mile or more away from the centre of the city, district heating is generally out of the question. On the other hand, a plant located near the centre of the city may, under certain conditions, supply customers within a mile radius.

As a general proposition, cities of 20,000 population or over have well defined and thickly settled business centres. This is also sometimes true of cities down to 10,000 population, but below this size it often happens that vacant lots, one-story buildings or temporary structures are so numerous that the income per foot of street main does not warrant the investment. It is evident that the farther away from the plant the customer is located, the poorer will be the service he receives; if steam is supplied the more moisture will it contain, and if hot water is used the lower will be its temperature when it reaches him.

The number of customers and the quantity of heat that they require, or, in other words, the density of the load, is an important factor which must be taken into consideration. This is largely governed by the class of business, whether residential or commercial. As a general rule, the commercial business is the better in every way, since not only is the income derived from it greater per foot of main, but the amount of heat required per cubic foot of space so used is less proportionately, for the reasons that the buildings are not used at night, are less exposed, and usually have thick masonry walls. Residences are generally exposed on all four sides, have large window area, and require heat twenty-four hours per day. The service runs for commercial business are almost invariably shorter than those for residences, and in many cases one such service can be arranged to serve two or more customers.

Changes in the population of his city should receive the manager's closest scrutiny, for if the city is growing rapidly it is essential at least to keep pace with its growing demands. On the other hand, it is a pretty safe rule that in a city which is at a standstill, or is falling off in population, one's investment should not be increased unless valuable economies can be effected thereby.

In a city not supplied with district heat, there comes a time when the undertaking of this branch of the business must be considered by the electric light company. If the opportunity is allowed to pass, it may be taken up by some new company as an entering wedge to serving the public, and perhaps greatly to the disadvantage of the older company.

A company just entering the heating field should be able, without much difficulty, to secure contracts for most of the buildings that are already piped. If exhaust (or live) steam is to be used, this does not entail any additional expense to the customer in changes to his installation; that is, if his building is piped for either hot water or for steam it can be handled from a district steam-heating plant. If, however, hot water is to be distributed, an installation arranged for steam will require remodelling before it can be so served. If the company secures all this business at the start, it has therein an excellent nucleus to work on; and as the popularity of the service increases and as furnaces break down, so the district heating business will grow.

An element of extreme importance in this consideration is the relation of the cost of steam coal to that of domestic coal. The greater the difference between the two in any given locality, the greater the profits to the company from the business, and the stronger the inducements to the consumer to use the district heat. In cities where steam coal costs from $1.00 to $2.00 and where domestic coal runs from $4.00 to $9.00, the company has much in its favor, and should be able to make rates that are at once attractive to the public and profitable to itself. With forty companies that report that they are doing a satisfactory business, the average price of steam coal is $2.18, while the average price of domestic coal is $5.74. Among these same companies, where the hardest operating conditions exist, steam coal is quoted at $1.17 and domestic coal at $1.50. On the other hand, one company reports that it pays but $4.00 for steam coal, whereas domestic coal costs $10 per ton.

It is a noticeable fact that most of the district heating plants in this country are located in the great middle belt. For obvious reasons, district heating systems are not required much to the south of Ohio, Indiana, Illinois, Missouri and Kansas, while in these states and to the east and slightly to the north they seem to flourish. That we find few plants in the extreme north is not so

much due to the fact that the average yearly temperature in these northern states is very much less than in the southern states, but because during the occasional periods of extremely low temperature every year, the demand upon the plant for heat becomes excessive, and unless people can rely upon plenty of heat at all times they will not become customers. A more attractive field for district heating is a location where the cold is not so extreme, but moderate and fairly steady.

The length of the season is a factor to be considered, especially when heat is furnished on any flat-rate system, *i. e.*, per square foot of radiating surface per season, per cubic foot contents per season, *et cætera.* When on a meter basis, however, the length of the season is of much less importance. It is well to avoid, in general, the making of contracts requiring heat during the summer months.

A city that is large enough to support a district heating plant is quite sure to have its streets already more or less occupied by water pipes, sewers, gas mains, telephone conduits, and, possibly, electric light subways. The location of these public service utilities should be carefully investigated, and with this information at hand correct large scale drawings should be made showing every obstruction, so that the best location for the district heating mains may be selected. Differences in elevation must be carefully ascertained, for with a hot-water district heating plant these are serious factors, though with steam heat they are of comparatively small importance, except that condensation in the mains and proper sub-drainage must be cared for.

Internal Conditions

What to do with his exhaust steam is a question for the manager to decide. Which is best: to install condensers and thereby increase the efficiency of the engines 20 per cent or more, and the capacity as well; or to sell this by-product as it is, in the form of heat? If the rates obtainable are fair, that is, if the heat can be sold nearly on a live steam basis, the plant should receive from the latter course at least three-quarters of the original value of the steam; while a condensing outfit would save but one-quarter to one-third of its value. If water for condensing is not available, the argument for district heating is strengthened. Very many plants have short and sharp winter peak loads; and it would

seem that under such conditions their managers might be warranted in installing some inexpensive, simple, non-condensing engines, the exhaust from which would be well utilized for heating purposes; or it might even prove to be best, under proper conditions of load and fuel costs, to install condensing apparatus which would be run during the summer, but which in the heating season would be cut out, the exhaust steam being then utilized on the heating system. The use of the exhaust steam for heating will necessitate the carrying of some back pressure on the engines, thereby reducing both capacity and efficiency, a point not to be lost sight of.

Before making the investment, the manager desires to know what income he may expect and how many square feet of radiation his exhaust steam will care for. Knowing the pounds of water per horse-power per hour consumed by his engines, and referring to his load curve of the previous winter, he can readily figure the minimum amount of exhaust steam that can be counted on for any single hour, and this should be the basis of his figures. Now come certain deductions: feed-water heaters and station leakage will probably take 15 per cent, while losses in mains and services may be as much more, though on the latter point we can cite one plant where the losses are less than 3 per cent.

The returns that we get from steam-heating plants indicate that it is safe to figure for ordinary conditions about .20 pound of water per hour per square foot of radiation (varying from .05 to .50). As all the consumers are not using the steam at the same time, particularly if on a meter basis, the load factor should be no more neglected than in the lighting business. Naturally, with the heating business this is higher; and if we use the figure of 85 per cent we shall probably be on the safe side.

Together with the above must be figured the interest charges on the total underground installation and that portion of the central station plant which is used for heating purposes; and lastly—depreciation—an item that is often neglected but which should nevertheless be estimated. From the best evidence at hand the last item seems to be about 5 per cent per annum on the total cost of the investment.

It is a well-recognized fact that a district heating system has often enabled a company to secure contracts for light and power which it would not otherwise have obtained. These then produce

an increase in load which in turn supplies more exhaust steam to sell for heat.

Though it is generally considered good practice to limit the heating business to that which can be taken care of by the exhaust steam, in many cases live steam has to be supplied at certain times in order to give good service. Where this condition exists and the demand on the live steam increases, it soon becomes necessary to set aside or to install a boiler solely for this purpose. Then comes the turning point of the plant. The chances are that it is selling live steam on an exhaust-steam basis, and it soon becomes evident, if the question is investigated, that there is no profit in the business. This condition of affairs has occurred repeatedly and in many cases has both cut down the net earnings of the company and given the heating business a bad name.

The lower the load factor of the plant, the less the inducement to undertake the heating business. In general, a railway plant is better adapted to care for district heating with its exhaust than is a simple lighting plant. As railway plants are generally located on the outskirts or in the country, the heating business may be considered as belonging more especially to lighting companies and must usually be cared for by them.

While it is true that the demand for heat comes at about the same time of the year as does the demand for light, yet it is also true that it may not come at the same time of the day that the plant is producing its maximum amount of exhaust steam; in other words, the lighting peak and the heating peak may not be coincident, and, in fact, there is no reason why they should be.

So long as the demand does not exceed the supply of exhaust steam, but follows it closely, and the rates are kept up, the plant is in a fair way to make money, but any plant that undertakes to sell live steam on an exhaust-steam basis is doomed to failure.

(2) MANAGEMENT OF A DISTRICT HEATING BUSINESS

While there are no essential differences in the principles of good management as applied to the supply of heat or of electricity from central stations, it is well to consider some of the special features in the management of a heating business that seem to have received insufficient attention and have been the causes of failure in some instances.

The problems of management properly begin with the incep-

tion of the enterprise, but it may be assumed for present purposes that the plant has been installed in accordance with the best practice of the day. It is probable that the heating plant owes its existence primarily to the fact that there is available a quantity of exhaust steam which it is proposed to utilize for heating buildings, thereby deriving some revenue from the heat otherwise wasted. To the facts that *any* revenue received from this source is looked upon as *net gain* and that managers fail to properly estimate the *real* value of the service to the consumer, are due most of the reports of unsuccessful ventures. Whether rates be by meter or per unit of heating surface or of space, the tendency is to estimate the cost of the service and its value too low. The consequence is that the heating account, if charged with its due proportion of expenses, shows a deficit. The evident remedy is to raise the rates, but if done sufficiently to put the business on a paying basis at once, this is an unpleasant task, although undoubtedly better than if done piecemeal.

That the service is of special value and is popular wherever introduced is evidenced by its rapid growth and by the many requests for extensions of mains and service connections with which every manager is favored without effort on his part of advertising or of soliciting. In many instances the absence of furnace smoke and dust makes the service worth twice its cost to a customer whose stock of goods is of a delicate character.

The insurance premiums are slightly lower, both on buildings and on stock, when the heating is supplied from outside sources rather than from furnaces or from local boilers.

It is essential, therefore, that rates be carefully fixed at the beginning of operations and that the cost of generating and distributing heat, plus proper investment, depreciation and dividend charges, be the basis of such rates. While it may be possible to compare with the daily and monthly load curves of the central station a hypothetical curve representing the amount of heat required by buildings of given dimensions, and thus estimate how much of the available exhaust steam can be utilized and how much live steam must be added, the result is at best an approximation. The only safe and reasonable rate is that based on the cost of supplying heat direct from the coal pile, or, in other words, on a live-steam basis. Any exhaust available with rates thus fixed can, of course, be used to advantage.

If the heating business is to stand upon its own merits, it is unwise to go into it on any other basis than that indicated above. If, however, it is the intention to supply heat where so doing secures good consumers of electricity and for the express purpose of getting such consumers, it brings up entirely different considerations. In this connection it is well to note that the heat required for buildings that might be consumers of both electricity and heat, is so great that even if all the exhaust steam of the entire plant were utilized for them there still might be a deficiency; in other words, the ordinary building requires more steam to heat it than to light it. It therefore behooves the careful manager to direct the growth of business on the heating system in the direction that will bring the greatest number of good consumers of electricity, and to this end all extensions of mains should be carefully considered, remembering that the supply of heat is limited. It naturally follows that the necessity for soliciting or advertising the heating business alone seldom exists after the first or second season.

It is advisable to limit the service connections made in street mains to the fewest possible, making extensions, wherever practicable, from service pipes in adjacent buildings, with due regard, however, for the capacity of the service from which the extension is made. For this and other reasons, it is essential that all service pipes, extensions of same and service valves should be laid and owned by the central station.

In the interest of satisfactory and economical operation from the consumer's point of view, all interior piping and connections to radiators should be installed so as to give complete and positive circulation, with minimum friction losses and without noise of any kind. To this end, it is well to publish standard regulations governing the character of the installations, and to give the prospective consumer all the assistance possible in the way of advice, sketches and specifications for the installation of his apparatus.

The same liberal policy should be followed in caring for complaints received from consumers, for by so doing it is easier to keep in touch with the character of the service and to remedy any defects, even if some troubles are thus taken care of which might properly have been referred to the plumber or steam fitter.

A careful inspection of all interior appliances, to make sure that everything is in proper condition and that the installation is

made in accordance with the requirements before the heat is turned on, is the best means of securing a satisfied customer and a minimum number of complaints.

The question of making the heating business a department by itself, with a separate system of accounting, is largely a matter of local conditions and of the size and importance of the enterprise. If made a separate department, the system of accounting would naturally parallel the existing system.

If the same degree of care is exercised in the management of the heating branch of the business and in its inception, development and conduct, as is shown in the other established and successful departments, there need be no reason to anticipate a failure.

(3) A COMPARISON OF RATES

Using the data at hand, an effort has been made to answer the following questions in regard to steam-heating rates:

(1) Can a definite relation be established between a meter rate and a flat rate under the same conditions of service?

(2) Should this rate be based on the number of square feet of radiation, or cubic feet of space heated, or the equivalent cubic feet of space heated?

(3) Should customers be charged the same flat rate independent of the kind of service, or should they be classified and charged accordingly?

Before examining the data, it seems advisable to consider certain general relations.

Theoretically, a meter rate is the only equitable method of charging, but practically it may be found that a flat rate will answer the purpose fully as well. The previous failures to produce a reliable meter had until recently prevented the general adoption of this system of charging, but from the success of the past year with new meters, and with the assurance from the manufacturers of still further improvements, it is probable that the meter basis of charging will become more popular.

When electricity is sold on a flat-rate basis, the consumer invariably leaves lights burning at times when they are not needed, simply because it adds somewhat to his comfort, for generally speaking, too much light is impossible. On the other hand, too much heat is not only possible but is nearly as bad as too little, and the consumer naturally takes pains to shut off the steam when

the room begins to be uncomfortable. Although there is a wide difference of opinion in regard to the amount of light required for proper illumination, it is generally conceded that the temperature of a room should not be far above or below 75 degrees Fahrenheit. This would seem to form a strong argument in favor of a flat-rate system.

If a flat rate is established, it is necessary to decide whether the rate shall be based on the square feet of radiation installed, or on the cubic feet of space, or on the equivalent cubic feet of space heated, which latter case takes into consideration windows, doors, masonry walls, *et cætera.*

Numerous formulæ have been worked out to give approximately the number of square feet of radiation that should be installed to heat various sized rooms under different conditions of service. It stands to reason, however, that the quantity of steam used to heat given spaces under similar conditions will be approximately constant and independent of the amount of radiation installed, provided that enough or more than enough radiation is supplied to take care of the coldest days. This would appear to be an argument in favor of basing the flat rate on the number of cubic feet or equivalent cubic feet of space heated.

Following is a summary of the information which we have collected; it is divided into three groups and all data are from metered customers:

Class of Service	Condensation per Sq. Ft. of Radiation per Day			Condensation per 1000 Cu. Ft. of Space Heated per Day			Ratio Cu. Ft. Space to Sq. Ft. Radiation	Av. Temp. °F.
	Av.	Max.	Min.	Av.	Max.	Min.		
Residences	3.83	5.20	1.79	51.3	75.2	27.4	76	34°
"	2.49	2.49	2.49	34.6	34.6	34.6	72	44°
"	1.69	3.22	0.54	..	..	..	..	..
Stores	4.48	10.1	1.01	29.0	50.2	11.4	115	34°
"	2.61	4.03	1.18	17.1	37.0	9.2	181	44°
"	1.94	3.77	0.64	..	..	..	..	..
"	2.32	3.4	1.8	20.0	28.5	13.6	136	40.5°
Offices	5.02	7.94	2.13	51.5	78.0	24.9	81	34°
"	2.92	3.70	1.73	25.1	32.2	19.7	120	44°
"	1.56	1.83	1.19	26.0	30.4	19.8	60	43.5°
"	2.27	3.62	0.89	..	..	..	..	..
"	2.97	3.8	1.8	29.0	49.7	14.9	111	40.5°

NOTE—While there is a large variation between maximum and minimum, it was found when making the tabulation that most of the figures ran very close to the averages given above.

The table shows that the steam consumption, as would be expected, is greatest where the average temperature is lowest and that this is an important factor to be considered in arriving at the rate to charge; that the kind of service makes very little difference in the steam consumption, although residences seem to have a greater condensation per cubic foot of contents and a less per square foot of radiation than either stores or offices; that the results, although varying widely, are near enough to justify the establishment of a flat rate, this being on the assumption (correct or incorrect)* that customers will use practically the same amount of steam whether on a flat or meter rate; and, finally, that if a meter rate is established a corresponding flat rate would vary according to the length of the season and average temperature, and may be easily approximated from the figures given.

(4) REGULATIONS GOVERNING THE SUPPLY OF STEAM FOR HEATING PURPOSES

INTRODUCTORY

These regulations are issued for the purpose of effecting an understanding between the company and its prospective customers, architects and steam fitters, regarding the requirements that in the interest of satisfactory service the company finds it necessary to impose on all installations to be connected to its mains. For the assistance of prospective patrons, the company is prepared to furnish specifications, upon which bids can be obtained for the installation of a properly designed heating system, and it is recommended that all who desire the service make application to the company for advice before installing a new system or remodelling an old one.

GENERAL

Steam will be supplied to those buildings situated along the lines of steam mains that are equipped with sufficient radiation to heat them to 70 degrees inside with outside temperature at 10 degrees below zero, and that have piping of sufficient capacity to freely circulate steam to all of the radiation under these conditions without pounding, surging or noise, due to the circula-

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*Mr. C. R. Maunsell is opposed to any system of flat-rate charging, and states that he feels safe in making the statement that his flat-rate customers (in Topeka, Kansas) use one-third more steam than customers similarly equipped paying by meter.

tion, with steam at a pressure of one pound per square inch at the service valve.

Contracts for heat will be made only with the owners of the buildings to be supplied, except where the steam-heating system installed supplies heat to a store-room only, in which case a contract will be made with the occupant of such store-room.

No contracts for heat will be made with the tenants of the upper floors of a building, nor will any contract be made for a shorter period than one year.

THE CONSUMER'S INSTALLATION

Piping and Radiators

The consumer is to own and maintain all the piping, radiators and appliances pertaining to the heating system inside the building, and the company reserves the right to cut off the supply of steam at any time when such piping, radiators and appliances are not maintained in good repair. The consumer is to pay for the connection between the company's steam service valve and his heating system; such connection to be made by the consumer after securing a written permit from the company.

New installations must be laid out on the one-pipe loop or circuit system, arranged to carry all condensation in the same direction as the flow of steam and to drain all condensation to a common point and into the trap. Where two or more drip pipes or returns are connected together, they must be trapped to form a water seal of sufficient depth to prevent steam from one interfering with the free discharge of water from the others.

All mains and branches must be securely supported on approved expansion hangers, substantially fastened to the ceiling.

The amounts of radiation that may be carried on mains and risers of the various sizes are given in the following table:

Diameters of Mains or Risers	One-pipe System. Supply Mains. Steam and Water Flow in Same Direction	Two-pipe or Overhead System. Supply Mains	One-pipe System Supply Risers	Overhead System Supply Risers	Two-pipe System Supply Risers	Two-pipe System Return Risers	Return Mains
1.25-inch	70	..	50	60	80	250	400
1.5 "	150	..	120	150	200	700	900
2 "	300	400	250	300	400	1,200	1,600
2.5 "	500	650	400	500	700	2,000	2,600
3 "	900	1,200	700	900	1,200	3,000	3,800
4 "	2,000	2,500	1,500	1,800	2,000	..	7,000
5 "	3,000	4,000	2,500	2,600	3,600	..	12,000
6 "	4,500	6,000	3,500	4,200	..	..	16,000
7 "	7,000	10,000	..	..	..	..	30 000
8 "	12,000	15,000	..	..	..	..	..
10 "	16,000	20,000	..	..	..	..	..
12 "	22,000	25,000	..	..	..	..	..

Branches from mains to risers and horizontal connections must be one pipe size larger than the riser supplied.

Each radiator must be provided with an approved automatic air vent, and it is recommended that all vents be connected to ventilating pipes for the purpose of carrying off the air and vapor which would otherwise be discharged into the room.

All pipes and fittings carrying steam should be covered with approved standard pipe covering, unless it is desired to use such pipes and fittings as radiating surface. As there is no way of controlling the heat when supplied in this way, it is not recommended.

All uncovered pipes are considered as radiation area at the following rates per lineal foot:

1 inch,	.343 square foot	3.5 inch,	1.047 square foot
1.25 "	.435 " "	4 "	1.178 " "
1.5 "	.497 " "	4.5 "	1.309 " "
2 "	.620 " "	5 "	1.456 " "
2.5 "	.751 " "	6 "	1.733 " "
3 "	.916 " "		

Trap

The consumer is to provide and maintain in good repair an approved steam trap of sufficient capacity to properly drain the condensation from the heating system of his building without

any loss of steam. This steam trap must be provided with an automatic air valve and a gate valve must be placed in the inlet pipe so that the steam may be cut off for repairs and examination, as occasion arises. There should also be a ground joint union in both inlet and outlet pipes near the trap. The trap must be so located that it will discharge by gravity into the cooling coil and with at least 6-inch head above the highest point in the coil or outlet from same.

Cooling Coil

The consumer must provide and connect to the outlet pipe of the steam trap a continuous cast-iron cooling coil, to be approved by the company, the surface of which must equal one-fifth of the radiation supplied with steam. This cooling coil must be connected as an indirect radiator, properly encased in galvanized iron and supplied with cold air in an approved manner, the heated air being carried to some part of the building where a constant supply of heat is required. The cold-air ducts must be provided with dampers and by-passes for use when steam is shut off. The cold-air ducts of cooling coils should have at least one square inch area and the hot-air ducts at least one and one-quarter inches area of cross-section for each square foot of cooling coil connected. Register faces must have a net area equal to that of the duct in which they are set. The pipe supplying condensation to the cooling coil must enter the coil at the highest point, and leave it at the bottom, and then be carried up above the cooling coil, but no higher than trap discharge, so that the cooling coil will at all times remain filled with water. The coil should be supported on a substantial iron pipe frame. The purpose of the cooling coil is to extract all the available heat from the condensation. It is an economy for the consumer, for it utilizes heat that would otherwise be wasted. Steam must not be shut off unless proper precautions are taken to prevent freezing the cooling coils. Where a supply of heat is required in the basement, and conditions permit the installation, cast-iron hot-water radiation is recommended in preference to cooling coils.

Meter

The consumer must provide a suitable location and connections and fittings for the condensation meter to be furnished and

set by the company. The outlet pipe from the meter to the sewer must be run as short and straight as possible, to give at least 12 inches fall between the meter and sewer opening and to be in size not less than the minimum requirement as given in the table below. The minimum requirements for height between centres of the meter inlet and outlet pipes are also given in the same table.

Maximum Square Feet Radiation	Size of Meters	Minimum Size Outlet	Minimum Height between Meter Inlet and Outlet
900	According to Manufacturers' Lists	2.5 inches	According to Dimensions of Meters
2,250		3 "	
4,500		3.5 "	
9,000		4 "	

More than 9000 square feet, special, and requiring more than one meter.

Meter outlet pipes must be connected to the sewer in a manner approved by the Plumbing Inspector for the Public Works Department of the city.

Permit

Steam fitters and all others are prohibited from making connections with the company's service pipes or in any way altering or interfering with them, without a written permit from the company, which will be issued only after a contract for steam has been signed and accepted by the company.

Inspection

Steam will not be turned on until an inspection of the apparatus by the company's inspectors has shown that the installation is in accordance with these regulations.

The consumer must guarantee the company's agents free access to the heating apparatus at all reasonable times, for the purpose of ascertaining whether or not the same is maintained in good repair and for the inspection and repair of service pipes, valves and meters.

THE COMPANY'S SERVICE

The company reserves the right to supply any other premises through such steam service pipe as it may deem advisable; if necessary, extending such steam service pipe through the cellar and walls of the consumer's building and into the cellars of adjoining buildings.

All such service extensions will be so made that the condensation will flow back into the street mains; or where this is impossible, the company will provide a separate steam trap to care for it. Such service extensions will be made at the company's expense and the company will repair any damage caused to the walls of the building in making them.

The steam service pipes, service valve, service extensions and meters will remain the property and in the control of the company.

Meter

The company will provide, set and maintain, free of charge to the consumer, the meter required to measure the condensation from the steam used.

Pressure

The company will be prepared, ordinarily, to furnish a continuous supply of steam at a pressure of one pound per square inch at the service valve, during the months of November, December, January, February, March and April. During the months of September and May steam will be supplied as required; but in case of unavoidable interruption from accident or other cause beyond the control of the company, the risk of such interruption is expressly assumed by the consumer.

The company reserves the right to cut off the supply of steam for non-payment of bills, for failure to comply with the foregoing regulations, and to guard itself against fraud or loss.

RATES

Steam will be furnished by meter only at the following monthly rates:

——— cents per 1000 pounds for all condensation up to 100,000 pounds
——— cents per 1000 pounds for all condensation over 100,000 pounds

Bills will be rendered monthly during the heating season from September to May, inclusive, and will be subject to a discount of — per cent if paid by the tenth of the month following that in which the steam was consumed. Discounts will positively not be allowed unless bills are so paid.

A minimum charge of $5.00 per month will be made, and no bill will be rendered for a less amount.

Respectfully submitted,

Committee, W. H. Blood, Jr., Chairman,
R. S. Wallace,
C. R. Maunsell.

DISCUSSION

The President: Gentlemen, this report is now open for discussion.

Mr. Maunsell: My name appears on this committee, but the committee is like all others—one man has practically to do all the work. I am sorry I was not connected more actively with the report, as I believe it is the most valuable report we have had on the steam-heating question; but, as the foot-note indicates, I differ somewhat with Mr. Blood in regard to the manner of charging, which, after the plant is installed, is the most essential feature outside of the consumer's piping system.

I want to make reference to one of the points. On page 414, the report refers to the use of steam on the meter basis. I will read from the middle of the page:

"The returns that we get from steam-heating plants indicate that it is safe to figure for ordinary conditions about .20 pound of water per hour per square foot of radiation (varying from .05 to .50). As all the consumers are not using the steam at the same time, particularly if on a meter basis, the load factor should be no more neglected than in the lighting business."

My experience in that regard, as the foot-note says, is that the customer will use from 25 to as high as 50 per cent more steam if he is on the flat rate. That is not so hard to overcome as the fact of the variation in rates. In my town we have had quite a little agitation on the subject of the variation in rates, some customers being charged by meter and some by flat rate. They naturally ask, "Why do you take some customers on the meter rate and others on the flat rate?" The reason why we place the majority of customers on the meter basis is because those installations would use an excessive amount of steam if

left on the flat rate. We have one instance where there is a store-room on the first floor, a restaurant in the rear of the store, and the upper floors are used for offices. The owner of the building determined he would not use steam taken from our company, and he allows the tenants to get along the best way they can. It is not good policy, but it exists, and it brought about this very condition of rate variation. The occupant of the store insisted upon having a flat rate. It was necessary to supply steam through a long main line, together with the necessary branches, before we could get steam into this store, and we refused to do it on the flat rate and insisted upon selling it on a meter basis. The merchant carried the point to the city council that we were discriminating in rates, and created an agitation.

I do not believe this committee can come before the convention advocating flat rates under any circumstances. We must do our business on a comparative basis. It seems to me that the matter narrows down to a question as to whether we are going to do the steam-heating business on a flat rate or a meter basis. Every man in the central-station business will run up against the variation in rates, and if we do not meet it in the way best for our interests, which way I believe to be the meter basis, we shall have to go out of the steam-heating business.

On page 415, the report refers to the sale of steam. A great many companies throughout the country have gone into the heating business expecting that it was all velvet, and in figuring on the selling of exhaust steam calculated how much the investment would be and how much return they must secure to pay interest and depreciation. If they would figure absolutely on a live-steam basis and sell it in that way, there is no question but it would be a success, as every plant thus operated is making a success of it.

The question of control of installations is one of most vital importance if you attempt to do any business on a flat rate. There is nothing that will bring home to a man so forcibly the extravagance of leaving the doors and windows open as a monthly reminder in the form of a bill. If the customer is careless in the use of steam, and allows the doors and windows to be open, he pays you a considerably lower percentage of profit on his business than if he were paying on the meter basis.

Mr. Gille: One point brought out by Mr. Blood I think is not very clear. He says that it is safe to figure for ordinary conditions about .20 pound of water per hour per square foot of radiation. I ask whether or not that has any reference to conditions of temperature, because there is no question but that the amount of coal required in the heating of a building varies directly as the difference in temperature. I ask upon what basis that is figured.

Mr. Blood: In answering Mr. Gille's question I would say that these figures are all based upon averages obtained by sending out a circular letter; and the figure of which he speaks comes from the average condition and average temperature in a number of plants. It does not represent one case or one locality. We simply attempted to give in this report certain general figures, so that a man might have a rough idea of what to expect. We also gave the maximum, the minimum and the average, so far as possible.

Mr. Gille: Would it not be better to state that on a certain degree difference of temperature?

Mr. Blood: That would be much better if we could get at it; that is, if we had sufficient data at hand to give the results. The data turned in by the companies in regard to steam heating are, I believe, about as meagre as any data you can mention. There are only a few companies that keep satisfactory records, and even these companies do not turn in their records any too promptly or completely.

Mr. James E. Pyle (West Chester, Pa.): In regard to the specifications for the pipes and radiators, I would say a few words. I have found that the steam-heating systems as a rule, whether fed from street mains or from boilers, are very unsatisfactory to the customer and to those using steam. We have found that the District Steam Company system of supplying steam heat to a building requires very much less radiation than is generally used from an ordinary steam boiler, and that the chief trouble with the whole thing is that it is not under control, the same as with the boilers in the cellar. We have introduced a system of control into our steam-heating plant, which is applicable to boilers as well, and it is of interest to every man who has a home or a store to heat, who uses steam either from a boiler or from the mains in the street. We take our pipes in

from the street and raise them to the highest point in the basement, go through a reducing valve and reduce the pressure to five ounces and hold it there. We raise the pipe to the highest point and drain it by gravity to the point where we want the water pipes to leave the building. Each radiator is equipped with three-quarter-inch pipe, with an indicating valve at the top of the radiator. We use water radiators only, and figure on 20 per cent more radiation than in the ordinary single-pipe system, and by using the valve at the top of the radiator, with an index on it that will show whether there is enough steam being admitted to heat one-quarter, one-half or three-quarters of the radiator. We can admit enough steam to give the required amount of radiation for any kind of weather. In that way we heat the top of the radiator when the valve is at point 1. The water is condensed and goes to the bottom of the radiator, which is cold, and before it leaves the radiator all the heat is used in the apartment being heated. The pipe from the radiator is connected to a small pipe in the basement, which has no connection whatever with the steam pipe except through a water loop that may drain the steam pipe. From there it is conducted to coils for the purpose of cooling the water condensed in the piping system only. Thence it goes to the meter. This gives the customer the advantage of regulating the amount of steam in all the rooms, independently, and to suit outside temperature, whether the weather is very cold or moderate; he can have the amount of steam he wants. The principal waste in steam heating is during mild weather, when large radiation is not required, and it is overcome by this method. We have found that our system operating on this plan is giving very much better satisfaction than the system operated on the single-pipe plan, and we are free to say that our customers' bills on this plan are at least 30 per cent lower than those on the single-pipe system. Our system is almost entirely equipped with this kind of piping, in every place. The only dissatisfied customers we have are those on the single-pipe system; the others like the service. They are heating on a basis of 40 cents per 1000 pounds of water, which is cheaper than they could heat with coal at $6.00 per ton. Some report a saving of 33 per cent over their coal bills. This system permits any company in the business to charge a rate proportionally higher and still give satisfaction, which is an important point for all steam-heating plants.

Mr. Maunsell: There is one point that has not been brought out as strongly in the report as I think it should be, and that is the consideration of the effect upon other business of supplying steam from a central station, or the effect on the steam business by the mere production of new electrical appliances. I attempted to bring out that point this morning in referring to the electric-heating apparatus. I think these points, and those of the supply of power and selling the exhaust steam, should be carefully taken into account by anyone who is considering the adoption of a steam-heating system.

The President: It has been customary, during the course of the convention, for the president to appoint a committee to nominate officers for the ensuing year. I will nominate as such committee, Messrs. Louis A. Ferguson, chairman; Paul Doty, Paul Spencer, N. F. Brady and Samuel Scovil.

It is requested that the committee report as soon as convenient.

The President: We will now take up the report on purchased electric power in factories, by Mr. E. W. Lloyd, of Chicago. I regret that Mr. Lloyd's health did not permit him to be present at this meeting. This is one of the most valuable numbers on our programme, and I will ask Mr. Gilchrist to read the report.

Mr. Gilchrist read the report, and at its conclusion said, "Mr. Lloyd desires to thank all the member companies for their co-operation in sending in the information from which he compiled the report."

REPORT ON PURCHASED ELECTRIC POWER IN FACTORIES

The subject "Purchased Electric Power in Factories" has received considerable attention from engineers in the past few years, and I believe it is now the consensus of opinion that the use of motors for driving machinery in factories is the most economical, practical and flexible known to date. The question as to whether the current for driving these motors can best be furnished from an isolated plant in the factory or from the lines of the central-station company furnishing power in the district, depends upon the rate per kilowatt-hour charged by the company, when the installation conditions are the same. I believe the time is near at hand when the greater part of factory power loads will be furnished from central-station service, as such great improvements have been made in central-station generating apparatus in the past few years that the selling price of electric current for power purposes has been reduced to the point where we can successfully compete with private plants.

In submitting the following report on electric power loads of a part of the central stations belonging to this association, it must be borne in mind by the members that it was necessary to eliminate some of the matter submitted, owing to the lack of complete information, and also that it does not at all represent the total amount of power furnished from all of the companies belonging to the association. The figures submitted are for average conditions, and, as far as was possible, mistakes in compiling these figures were avoided. I do not think central-station managers have much difficulty in obtaining power customers up to 10 or 15 horse-power, as the cost of running motors of this size is generally below the cost of running a steam engine or other prime mover now on the market, particularly when all of the items that go to make up the operating cost are taken in consideration. Even though the cost of furnishing current to small consumers were a trifle greater from the central-station service, we should have very little difficulty in obtaining this class of business, as a factory owner would rather not be bothered with

the power question and prefers to pay a little more if he is satisfied he will have no trouble. It is, therefore, with the larger installations of motors in factories that run from central-station service that this paper will treat.

The question as to whether a factory will run from central-station service or whether it will generate current from its own plant is not always decided by the rate per kilowatt-hour which the central-station company proposes to charge for the current. To any one who has had experience with installations of motors driving machinery, where one large motor was used, it is known that no economy can be obtained over engine drive with profitable rates for central-station service. It may be possible with the use of a few motors in a large plant running 15 to 24 hours a day with a low rate per kilowatt-hour, that central-station power can compete with engine drive; but the average plant does not run more than ten hours a day, and, therefore, the rates of a central-station company doing a profitable business can not compete successfully with these conditions. It is, therefore, necessary to consider other sides of the factory power subject than merely the question of price per kilowatt-hour.

The most important fact that has been developed to-day in connection with this subject is that the proper motor installation has everything to do with the economical furnishing of electric current from central-station service. I think central-station managers will agree that in a great many cases where factory power was lost to them the fault lay in the fact that the motor installation eliminated none of the wastes in the plant that were in evidence when it was driven from an engine. A great many cases of this kind have come to my notice, and I am fully convinced of the truth of these statements. While it is no doubt difficult to convince factory managers that the installation of a great many motors is the only economical method of driving, this is being accomplished by a number of companies, and it is becoming less difficult each day to demonstrate the efficiency of individual or good group-drive installations of motors. The elimination of all friction loads in a factory makes a wonderful difference in the kw-hour consumption. I believe the time is coming when machinery of almost every description will be equipped with electric motors before it is put into service. It is a well-known fact that the efficiency, flexibility and output of a

tool is materially increased with the use of individual motors. While it is true that the installation of individual motors increases the connected horse-power load in a given factory over and above what it would be should group-drive installation be made, it is also true that the current consumption is considerably less on the individual-motor installation. There are engineers throughout the country who advocate individual-motor installation, but I believe the subject has not received the proper consideration from all central-station companies, and the sooner it is brought forcibly to their attention that this type of installation will do more to increase their power load than any other one thing, the more universal the practice will become. The selling by some companies of electric current at very low rates even to the extent of losing money on this current is not necessary with proper motor installations. Extremely low prices for electric current in some localities are detrimental to the station business in others, and I do not think they are necessary if the proper attention is given to the engineering features in obtaining power business.

The agent sent out by the central-station company to obtain large business must have some training before he is competent to get business. It is necessary to make a special study of factory conditions. Starting in the engine-room he must understand the coal consumption of different types of boilers and the steam consumption of the different types of engines. While it is very likely he can obtain from most factory managers the coal consumption in the plant, it is very necessary that the agent know whether this coal consumption is correct or whether it is abnormal considering the engine and boiler installation. If the coal consumption per horse-power be high it is a point in favor of central-station service. It must be taken into consideration that in a great many plants they do not always keep a correct record of the plant costs, and, in view of this fact, it is necessary to know what items go to make up these costs. The mere costs of fuel and labor are not by any means all of these costs. The items enumerated below are those that can generally be considered as making up the total cost of operating an isolated plant:

Salary of engineers
Salary of firemen
Salary of electrician
Fuel

Removal of ashes
Water
Oil
Repairs to boilers
Repairs to engines and dynamos
Lamps
Carbons
Tool account
Miscellaneous expense and supplies, waste, packing, *et cætera*
General expense
Depreciation (10 per cent to 15 per cent)
Interest on investment
Insurance
Rental value of space
Damage resulting from heat and vibration
Risk to employees and the public through accidents and boiler explosions
Taxes

In addition to the above plant costs, it is often necessary to add the following:

Maintenance of rope or belt transmission lines
Unnecessary investment in shafting and hangers
Salary of millwrights

If the factory manager has not kept a correct account of the above items it is necessary that the agent be familiar with plant costs and also with the operation of the machinery in the plant, and be able to estimate these costs. He must, furthermore, understand the operation of different kinds of machinery and know approximately what power each machine takes. This may seem a difficult proposition for the station manager who has to hire solicitors, but an intelligent agent can accumulate a surprising amount of information in this direction in a year. There is so much matter published by the different manufacturers of apparatus and also by the different techincal journals on the subject of motor installations that a great deal of matter can be obtained from these sources. It is extremely difficult to determine at times what the average power consumption on a given plant would be if the friction loads were eliminated. Taking indicator cards from an engine for one day, or even for one week, does not

determine the average load nor the friction load throughout the year, as the factory may have dull periods when the average load will be less and the proportionate friction load more; not only that, but the large friction load on the average plant can not easily be determined, owing to the impossibility of cutting off all the running belts and countershafting. In arriving at the power consumed by a factory having engine drive it should be remembered that should the proper motor installation be made a large percentage of the friction loss would be eliminated. If the agent is familiar with the character of the business carried on by the manufacturer desiring figures on central-station service, he can obtain very accurate information on the probable kw-hour consumption, by making an observation of the character of the work done by each machine and probable hours of running. He can then arrive at a fairly accurate estimate of the kilowatt-hours per day required by each machine. A machine may run all day and still not average more than 50 per cent of the maximum.

One of the most difficult propositions an agent will meet is where a factory is equipped with fairly efficient engines and where there are a great number of machines in operation. The factory manager objects seriously to spending a great deal of money on small motors for the operation of his plant, and it is often necessary to guarantee results from such an installation for a short period in order to convince him that you are accurate in your estimate of the kilowatt-hours per month.

Another of the most difficult tasks we have is convincing a customer that his average load is not equivalent to his connected load, nor is his maximum load the average. It is surprising what a large number of people persist in these views.

Factory managers are appreciating more and more every day the advantages of electric drive, and it is not nearly so hard a job to induce them to-day to change over to motor drive as it was a few years ago when there were comparatively few large plants in the country equipped in this way.

In equipping a factory with motors it is also necessary to use a fairly efficient motor. If poorly-designed motors are used there can be a great loss of current in the motors themselves, and while it is true that manufacturers are making the average motor more efficient to-day than it ever was made, it is well to consider the matter of efficiency and see that the motors to be

used are of a good make. This point is not always given proper consideration by the central-station agent or the factory owner. Very frequently the factory owner has some friend in the motor business who induces him to use motors that are not as efficient as they should be.

It is not always the question of electrical efficiency, however, that should govern the make of motor to be used. If the motor is poor mechanically, it can cause more trouble in the course of a year than would the lack of electrical efficiency. The average factory superintendent does not understand electricity, and when motors are first installed in his factory and he has trouble with the motors from different causes, he is very apt to become prejudiced against central-station service on this account. The troubles with brushes, commutators, brush-holders and bearings are most frequent where direct-current motors are used. With alternating-current induction motors, troubles are of infrequent occurrence and do not require the consideration and attention the direct-current motor does.

The speed of the motors for driving machinery should be considered and the method of driving machines should receive the careful consideration of the agent handling the job. While it is not absolutely necessary that the central station install these motors, I believe they should have some voice in the matter, and the factory owner convinced that the advice of the central-station company is for his best interests in making the installation practical and economical. Where the company has a construction force for carrying on commercial electrical construction this department can be used to great advantage in this work. A part of this construction force can be educated in the installing of motors, and efficient work on their part will do a great deal toward keeping the customers satisfied.

In connection with motor installations in new factories, it should be borne in mind that there will be a considerable saving in the first cost of the building and equipment by the removal of heavy line shafting. The cost of belts and pulleys and their maintenance is also eliminated to a large extent by the use of motors.

When endeavoring to convince a factory owner that he should accept central-station service, his attention should be called to the fact that there are other reasons besides saving

in cost of current that should convince him that this service is to his advantage—such as the elimination of smoking chimneys; inability to get coal should there be strikes; breakdown of the transmission shafting, stopping the entire plant; breakdowns of engines or boilers; the liability of accidents in the plant from explosions or other accidents; cleanliness; the absence of belts, vibration and heat; and, as before stated, the increased efficiency, flexibility and economical operating of the machines throughout the factory operated by motors. The output of a tool can be materially increased by such installations, and, therefore, the investment in tools decreased for a given output. Furthermore, there is the reliability of service from the central station at any time during the twenty-four hours. Should he have a particular contract where it is necessary to run a few machines in order to turn out goods, he can run this part of his factory very economically, it being only necessary to use such motors as are direct-connected to the machines that are required to do such work. There is also the fact that should his business increase it is only necessary to expend a small amount of money in order to increase the capacity of his power plant, instead of buying a new generating unit or of running a very large engine on an uneconomical load for a number of years.

While it may seem that an agent having all of the above qualifications and knowledge relative to machinery in power plants would be an expensive adjunct to the force of a central-station staff, experience has demonstrated to a number of companies that this man can be developed in a surprisingly short time by education and by putting before him compiled information from the company's books on the consumers already furnished current from central-station service. Do not stunt the growth of your business by withholding information from your agents. The compiling of this information should, I believe, be carried out on the same lines by all members of this association.

The data sent by the different companies to make up the information in the latter part of this report would not indicate that such information had been compiled in a thorough manner. I believe it of great benefit to any manager of central-station properties to have at hand information of his larger power customers that can be used in obtaining new business. If a

prospective customer knows that you are running a competitor from your lines, and you are free to tell him what the approximate costs of such service are per horse-power, it is much easier to convince him to sign a contract than it would be if you had no examples or no information to show him. On the opposite page is shown a form compiled to take care of power information, which may be of some assistance in the collecting of such information by different companies.

This card system can, of course, be modified to suit the requirements of the company that decides to compile such data.

While it is true that average loads on different kinds of business are not the same throughout the year, still it is true that averages obtained from the company's books over a period of a few years on any kind of business should be of great value to the central-station manager. It is impossible to fix any hard and fast rules on the average load of any business, but you can at least form an idea as to the approximate kilowatt consumption of a given plant. If he did not have such information before him it would be necessary to rely absolutely on the estimates or on expensive tests which may be incorrect. While engineers can make estimates that are very close, still there are, no doubt, times when he is mistaken in such estimates and it is not always possible for every company to obtain moderate-priced men who can make such estimates accurately in the majority of cases.

In looking over the information sent by the different companies you will notice that there are some lines of business to which the central station furnished little or no power. As the selling of power from central-station service is still in its infancy, this is not surprising; in fact, it is more surprising that the central-station companies have obtained such large power loads in so few years. Experience in some lines would indicate that it will be necessary to give better rates on these classes of business than on others, in order to increase the central-station loads in that direction. On machinery such as large blowers, refrigerating machinery, air-compressors, running ten hours or more, or any other machines that have a very high average load during their period of operation, the price per kilowatt-hour must necessarily be less than for machines such as punches, lathes or other tools, where, no matter how continuously they are operated, the average load is only a small part of the maximum load.

A B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

NAME..
ADDRESS..
BUSINESS..
Supt., Mgr. or Party to see..

Date.......... ....Cards. Card No....
Motor installation distribution by.......... ....
Is installation efficient?......................
Individual or Group Drive   Running hours per Week Month

LIST OF MOTORS AND MACHINES DRIVEN

No.	H.P.	V.	A.C or D.C.	Make	For Driving	On Meter No.
......	......	......	......	....	....	....
......	......	......	......	....	....	....
......	......	......	......	....	....	....
......	......	......	......	....	....	....
......	......	......	......	....	....	....
......	......	......	......	....	....	....
......	......	......	......	....	....	....
......	......	......	......	....	....	....
......	......	......	......	....	....	....

Remarks:
....
....

	K. W. Hrs.	K. W. Max.	Net Bill	K. W. Hrs.	K. W. Max	Net Bill	
Jan......	....	....	....	....	....	....	......
Feb......	....	....	....	....	....	....	......
Mar......	....	....	....	....	....	....	......
Apr......	....	....	....	....	....	....	......
May......	....	....	....	....	....	....	......
June......	....	....	....	....	....	....	......
July......	....	....	....	....	....	....	......
Aug......	....	....	....	....	....	....	......
Sept......	....	....	....	....	....	....	......
Oct......	....	....	....	....	....	....	......
Nov......	....	....	....	....	....	....	......
Dec......	....	....	....	....	....	....	......
Total......	....	....	....	....	....	....	......
Average......	....	....	....	....	....	....	......

Total installed H. P....Ave. cost per month per installed H. P.... Load factor.... per cent
Remarks:..
....
....

The following report is made up as showing the average load as indicated by the figures submitted by the different companies, and while making up the figures it was not possible to get as large a number of factories for each class of business as was desirable; still the figures show very fair average conditions and are approximately correct.

I do not think it makes any difference in the average load of a given plant as to whether it be located in New York or San Francisco. Of course in making up figures on average loads it must be assumed that the factory is busy and that the motor installation is about the same in numbers and layout.

Nowadays, in order to make a success of any business in the manufacturing line, it is necessary to get all the work out of tools or apparatus that is possible. A factory working under other conditions will not last long and therefore contracts with this class of customer are not desirable from the central-station standpoint, as the average load in a dull factory is very low.

The table below is compiled from information submitted from different cities all over this country and while it is probably not conclusive is better than the small amount of data we have had up to this time.

BAKERIES

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,500	20	Group	2	40
4,166	87	"	8	24.8
2,202	100	"	7	12.3
703	10	"	1	36
557	20	"	2	14
1,203	25.5	"	5	46.7
333	14	"	2	24.9
436	10	"	1	23.2
2,327	70	"	2	28.5
912	8	"	2	70
2,798	50	"	3	29.8
363	15.5	"	3	13
991	21	"	2	26.2
430	15	"	1	16
373	13	"	2	16
5,800	60	"	3	20
1,099	20	"	1	33
26,393	559		47	Total
1,582	32.8		2.7	27.8 Average

BAKERIES

605	15	Individual	2	24.2
95.6	10	"	1	12.7

Bakeries—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
375	9	Individual	3	25.2
980	18	"	4	28
432	26	"	3	8.4
218	20	"	2	26.7
2,687	65	"	7	22
250	17	"	3	8.9
5,642.6	180		25	Total
705.3	22.5		3.1	19.5 Average

Boiler Shops

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
11,411	177	Group	6	36.8
11,104	115	"	4	49
1,293	30	"	1	24.7
1,312	12	"	2	58.4
813	10	"	1	41.5
987	50	"	1	13.2
400	15	"	1	11.9
682	15	"	1	24.2
1,635	20	"	1	54.5
1,266	27.5	"	2	23.7
5,034	94.5	"	11	28.4
35,737	566		31	Total
3,267	51.4		2.8	33.3 Average

Boiler Shops

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
330	10	Individual	3	20
1,470	40	"	7	18
400	15	"	3	15
1,666	40	"	5	22.2
2,000	56	"	8	28.5
5,860	161		26	Total
1,172	32.2		5.2	20.7 Average

Boots and Shoes

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
2,338	50	Group	11	23.8
246	5	"	5	21.2
100	5	"	1	10.4
3,000	20	"	2	76.9
391	5	"	1	40
1,156	15	"	1	46
8,840	97	"	6	55.5
5,765	157	"	24	22.2
503	10	"	1	28
4,680	40	"	4	67
1,048	13	"	3	49
4,525	45	"	14	51
7,063	55	"	3	66
39,655	517		76	Total
3,050	39.7		5.8	42.8 Average

BLACKSMITHS

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
446	10	Group	1	29.8
410	5	"	1	42
1,230	10	"	2	73
403	5	"	1	41
1,311	26.5	"	5	29
140	6	"	1	20
457	20.5	"	8	11
300	6	"	1	26
150	5	"	1	25.8
1,223	30	"	1	41.7
416	10	"	3	37
555	9.5	"	2	35
7,041	113.5		27	Total
586	9.4		2.2	34.2 Average

BOX-MAKING

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
572	5	Group	1	61
2,573	25	"	1	55
1,020	17	"	2	36.5
515	8	"	3	31.8
717	10	"	3	42.5
1,250	20	"	1	32
300	5	"	1	32
500	10	"	1	46
198	5	"	1	24.6
854	15	"	1	30.4
202	10	"	1	13
7,111	34.5	"	4	82.8
2,113	40	"	5	50
2,062	18	"	2	65
1,816	16	"	2	65
1,000	10	"	1	54
278	5	"	1	33.9
273	5	"	1	28
1,666	10	"	1	89
6,086	94.5	"	54	37
31,106	363		87	Total
1,555	18.1		4.3	45.4 Average

BRASS-FINISHING

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
807	17	Group	2	25.3
30,040	250	"	52	63.8
141	5	"	1	15
2,290	25	"	2	48.8
250	75	"	1	10.7
12,246	82	"	3	83
4,978	60	"	3	44.3
357	3	"	1	79.5
514	15	"	2	35.2
51,623	364.5		67	Total
5,736	40.5		7.4	45 Average

Butchers and Packers

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
416	15	Group	1	14.7
371	15	"	1	14
912	7	"	3	74.5
10,900	100	"	2	58.4
3,900	41.5	"	4	50
661	55.5	"	5	6.6
730	10	"	1	13
245	10	"	1	14.8
3,468	10	"	1	97
666	15	"	2	17
1,776	14	"	2	24.6
1,146	15	"	1	63.6
686	15	"	1	25.4
25,877	323		25	Total
1,990	24.8		2	36.4 Average

Butchers and Packers

195	12	Individual	3	10
245	10	"	1	14.8
1,900	15	"	1	22.5
2,181	96	"	19	12.6
940	55.5	"	13	12
1,624	59	"	14	46.8
807	26	"	5	15.7
444	14	"	1	17.6
640	20	"	1	19
1,518	51.5	"	9	17
10,494	369		67	Total
1,049	36.9		6.7	18.8 Average

Breweries

75,000	440	Group	11	33
333	15	"	3	11.4
6,826	107.5	"	6	38.5
10,186	65	"	4	37.4
357	5	"	1	47.7
990	34.5	"	5	15.9
1,720	65	"	2	14
3,000	25	"	5	66.6
98,412	757		37	Total
12,301	94		4.6	33 Average

Carpet-cleaning

166	5	Group	1	17
900	7.5	"	1	53.3
166	12	"	2	24.7
281	3	"	1	26.7
400	10	"	1	52.8
1,118	15	"	3	27
500	30	"	3	9.2

CARPET-CLEANING—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
441	18	Group	2	18
1,333	15	"	1	45.6
1,000	44	"	3	14
300	5	"	1	29.8
1,126	15	"	1	43
7,731	174.5		20	Total
644	14.5		1.6	30.1 Average

CEMENT-MIXING

2,147	35	Group	1	17
1,500	35	"	1	22.9
8,051	50	"	1	36.2
1,321	30	"	1	22.6
8,119	150		4	Total
2,009	37.5		1	24.9 Average

CANDY MANUFACTURING

340	13	Group	1	42.9
1,228	14	"	1	26.6
583	11	"	3	20.8
6,666	37	"	3	92.5
773	22.5	"	2	14
233	8	"	2	16
4,868	74	"	6	35.1
132	3.5	"	2	29.6
800	18	"	3	30
3,316	65	"	12	29
18,939	266		35	Total
1,893	26.6		3.5	33.6 Average

CANDY MANUFACTURING

270	13	Individual	2	12
982	50	"	8	11
425	22	"	6	9.9
127	5.5	"	4	14.1
424	21	"	6	12
691	25	"	4	16.5
1,070	20	"	3	29.5
2,376	83	"	27	26
6,365	239.9		60	Total
796	29.9		7.5	16.3 Average

COTTON MILLS

14,007	95	Group	2	74.1
14,620	112.5	"	5	65.3
6,860	90	"	2	41
35,487	297.5		9	Total
11,829	99		3	60.1 Average

Carriage and Wagon Works

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
500	8.5	Group	3	31.8
4,147	121	"	14	91.1
562	15	"	2	25
174	5	"	1	23.2
333	10	"	1	16.7
912	10	"	1	60.8
400	3	"	1	86.8
881	15	"	2	30
5,000	50	"	2	53.2
771	20	"	2	23.2
1,680	20	"	2	43
552	25	"	1	12.2
200	5	"	1	20
937	18	"	1	29
253	5	"	1	26
2,251	15	"	1	83.5
24,000	250	"	30	71
761	7.5	"	1	38.3
280	5	"	1	37.4
625	10	"	3	20.8
230	7.5	"	1	13.5
567	20	Individual	6	18
46,016	645.5		78	Total
2,091	24.8		3.5	35.5 Average

Chemical Works

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,055	20	Group	1	30
13,328	407.5	"	16	18.2
228	13.5	"	3	11.2
4,322	54	"	2	46
8,682	120	"	4	13.3
1,189	40	"	7	21
28,814	655		33	Total
4,802	109		5.5	23.5 Average

Clothing Manufacturing

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
833	15	Group	3	37
11,900	53	"	6	86
1,670	21	"	4	48.3
1,746	12.5	"	2	78.2
5,948	107.5	"	17	30.7
6,165	102	"	18	30.8
1,430	30.5	"	5	30
1,240	35	"	3	23
880	10	"	1	47
733	5	"	2	82.7
2,500	15	"	3	89
558	20	"	2	14.9
254	5	"	1	27
220	5	"	1	35.2
536	13	"	3	33.4

Clothing Manufacturing—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,169	15	Group	2	39.9
300	5	"	1	32
3,300	50	"	3	11
505	27.5	"	3	33.7
1,321	11	"	2	66.7
4,050	56	"	11	37.1
678	7.5	"	1	50.2
737	10	"	1	40.8
480	5	"	1	53
583	4	"	1	77
900	9.5	"	6	51.4
2,800	15	"	2	100
900	25	"	1	19.2
666	15	"	1	24
1,033	15	"	1	37
1,700	18	"	4	50.3
485	12.5	"	7	22.1
1,736	21.5	"	18	49
60,780	783		138	Total
1,181	23		4	44.5 Average

Grain Elevators

1,441	35	Group	4	24.8
618	35	"	1	19.6
1,562	60	"	5	12.6
2,800	65	"	2	26
656	30	"	1	13.2
139	10	"	1	15.4
2,680	30	"	1	47.6
3,333	50	"	5	50.8
1,797	65	"	1	30.7
11,294	240	"	4	25.2
416	15	"	1	16
625	13	"	1	31
3,875	65	"	4	53
516	5	"	1	53
1,512	25	"	1	36
4,957	140	"	8	36.3
2,303	35	"	1	73
105	15.5	"	3	41
32,765	1,240	Individual	27	14.3
73,004	2,173.5		72	Total
3,842	114.4		3.8	32.6 Average

Feather Cleaners

1,697	35	Group	1	27.5
3,197	73.75	Individual	10	24
4,894	108.75		11	Total
2,447	54.37		5.5	25.7 Average

General Manufacturing

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
344	10	Group	1	27.4
609	12	"	1	28.2
8,317	96	"	8	44
3,552	35	"	2	52
444	20	"	2	12.2
2,900	51	"	7	37
2,510	53	"	13	24
500	26	"	4	10
31,420	100	"	1	73.4
30,560	115	"	5	56.7
575	20	"	1	14.7
1,231	20	"	1	31.7
9,502	125	"	4	38.9
579	5	"	1	58.4
775	5	"	1	82.8
636	10	"	1	42.4
1,041	15	"	1	37
338	8	"	2	22.5
5,378	30	"	1	95.7
600	40	"	2	17.3
768	20	"	1	25.6
234	25	"	2	9.6
243	4.5	"	2	35.4
1,059	27	"	4	24.9
5,417	144	"	17	29
1,730	31.5	"	6	28
277	16	"	2	10.5
781	20	"	1	18.5
3,141	50	"	3	38
4,583	50	"	1	48.8
500	10	"	1	26.7
1,727	20	"	1	52.3
100	25	"	1	26.7
1,583	5	"	3	57.8
500	6	"	2	63.5
388	5	"	2	47.2
13,011	130	"	11	60
600	15	"	1	20.5
541	10	"	1	27.8
541	20	"	2	15
500	10	"	1	25.6
834	15	"	2	37
179,560	1,643	"	122	62.3
73,777	1,329	"	222	31.2
13,565	242	"	20	31.6
130	7	"	4	11.2
225	11	"	2	12.4
291	3	"	1	58
6,221	42.5	"	3	88.7
2,321	72	"	24	17.3
6,900	105	"	7	28.6
3,130	20	"	1	80
358	4.5	"	3	46
440	4.5	"	1	48.4
3,604	60	"	7	36.5

GENERAL MANUFACTURING—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
614	22	Group	3	14
736	12.5	"	2	31.3
254	5	"	1	27.3
547	8	"	2	27.3
157	5	"	1	38
1,720	25	"	2	48
1,506	30	"	1	25.6
600	15	"	1	20.4
456	15	"	1	12.7
735	10	"	1	40.8
1,533	30	"	2	28.4
911	10	"	1	50.6
300	15	"	1	11
1,120	10	"	1	62.2
743	21	"	1	19.6
5,033	55	"	7	50.8
442	20	"	1	12.3
1,922	40	"	3	26.7
780	10	"	1	43.3
800	15.5	"	2	28.5
627	10	"	1	34.8
386	10	"	1	21.4
612	10	"	1	34
250	10	"	1	14
330	12.5	"	2	14.6
541	10	"	1	36
1,159	15	"	1	43
412	7.5	"	1	33.2
375	10	"	2	19.2
2,416	50	"	1	22.6
250	5	"	1	25.7
208	5	"	1	21.4
2,083	98	"	17	12.5
3,333	20	"	4	85.5
408	6	"	2	87.5
16,650	750	"	12	11.9
16,666	350	"	50	25.5
8,206	100	"	6	48
2,907	42	"	5	41.8
1,341	15	"	3	53
270	7.5	"	1	26.2
983	16	"	3	40.8
1,112	20	"	1	32
851	31	"	6	15
466	13	"	1	21.8
8,051	71.5	"	10	72
774	11	"	4	36.9
1,960	30	"	1	33
2,134	15	"	1	73
2,730	55	"	2	30
3,765	72	"	8	31.7
460	6	"	2	47
1,332	35	"	3	23
21,491	215	"	2	26.5
3,360	87.5	"	4	14
999	20	"	1	26

GENERAL MANUFACTURING—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
400	7.5	Group	1	27
770	20	"	1	23.3
707	33	"	4	12.9
650	25	"	1	17.3
1,117	58.5	"	2	11.6
312	10	"	3	18.9
1,725	36	"	3	24.6
3,880	32.5	"	3	66
1,338	32.5	"	6	22.8
1,147	14	"	12	45.5
280	13	"	2	11.5
175	10	"	1	23.3
370	7.5	"	2	25.2
290	5	"	1	28.8
233	5	"	1	37.8
3,600	83	"	8	23.1
810	29	"	5	20
1,462	34	"	10	25
11,604	250	"	5	30
1,586	26	"	11	36.8
378	7.5	"	1	28
1,652	25	"	2	36.6
1,825	25	"	1	50
1,219	50	"	2	24.9
771	30	"	1	14.3
350	5	"	1	35.8
416	7.5	"	1	42.5
29,332	275	"	4	21
234,000	500	"	1	94
916	25	"	1	18.5
416	12.5	"	1	16.6
4,166	48.5	"	8	50
16,666	360	"	12	23
833	12	"	2	27.6
436	39	"	8	17
6,640	82.5	"	11	44
3,000	85	"	3	20
200	5	"	2	24
200	5	"	1	24
45,624	225	"	8	44
2,861	76.5	"	12	21
13,100	95	"	6	52
1,516	27	"	4	55
432	15	"	1	17.6
666	12	"	2	30
826	8	"	2	69
277	16	"	2	10.5
12,246	82	"	3	83
3,327	28.5	"	12	32.3
1,083	39	"	3	14
1,400	23	"	4	74
5,234	60.5	"	8	49
7,884	120	"	6	37.8
45,977	380	"	13	68.8
1,727	20	"	1	52.3
15,000	40	"	3	19

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General Manufacturing—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
13,011	130	Group	11	60
388	5	"	2	47.2
9,893	173	Individual	21	25
4.017	213.5	"	14	11.4
22,864	28.5	"	5	6
1,666	35	"	1	25.4
341	25	"	1	7
1,050	56	"	18	10
625	29	"	5	11.4
1.982	75	"	11	15.1
10.291	197	"	43	21
326	5	"	4	40
3,485	67	"	27	30
2,929	60	"	28	28
1,110.128	12,231.5		1,167	Total
6.133	67.5		6.4	33.9 Average

Engraving and Electrotyping

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1.350	23	Group	7	33.6
433	10	"	1	24.1
375	6	"	2	45
868	20	"	1	57
833	6	"	4	74
289	7	"	2	22
1.077	12	"	2	59
1.680	15	"	1	60.8
6.905	99		20	Total
863	12.4		2.5	46.9 Average

Engraving and Electrotyping

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
938	30	Individual	23	15
1.415	39	"	25	23
10.927	162	"	91	40
1.728	52.25	"	31	18.6
787	15.5	"	8	28.2
223	12	"	3	10.2
566	13.5	"	6	22.6
16.584	324.25		187	Total
2,369	46.3		26.7	22.5 Average

Glass-grinding and Beveling

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
873	15	Group	2	34
4.352	22	"	4	42.2
103	5	"	1	45.7
427	25	"	1	10
5.000	70	"	1	38
5.795	64.5	"	10	50
16.550	201.5		18	Total
2.760	33.5		3	36.6 Average

FOUNDRIES

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
2,665	38	Group	5	38
1,602	50	"	4	18.9
1,747	35	"	3	33
763	15	"	1	28.2
833	10	"	1	47.5
4,301	50	"	3	49
830	35	"	2	63.3
6,691	60	"	2	57
936	15	"	1	35
635	8	"	1	70.7
4,301	62	"	3	39.6
583	7	"	2	47.8
1,850	20	"	1	47.4
470	7.5	"	1	33.5
2,660	33	"	5	47
30,867	445.5		35	Total
2,057	27.7		2.3	43.7 Average

FOUNDRIES

2,490	56	Individual	5	23
5,000	145	"	4	18.4
2,511	159	"	21	10
15,237	610	"	45	14.2
1,663	80	"	4	14
166	5	"	3	17
3,305	88	"	13	21
1,106	45	"	4	12
5,397	85	"	10	36
756	22.5	"	3	20
290	7.5	"	1	14.9
230	5	"	1	23.6
541	5	"	1	57.7
833	15	"	1	28.6
318	10	"	1	21.7
1,250	45	"	3	17.8
1,166	35	"	1	17.7
1,284	42.5	"	4	16.7
43,543	1,460.5		125	Total
2,419	81.1		7	21.3 Average

FURNITURE MANUFACTURING

200	5	Group	1	28
1,052	20	"	3	28.2
2,800	55	"	2	33.9
2,460	25	"	1	50.8
2,751	70	"	6	25.6
1,690	42	"	5	22.8
1,455	40	"	6	18
614	35	"	6	18
2,735	29.5	"	3	95.7
15,757	322		33	Total
1,750	35.7		3.6	35.6 Average

Flour Mills

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
2,830	25	Group	1	60.2
2,083	20	"	1	68
428,265	1,091	"	16	99.6
25,554	110	"	2	99.2
4,617	65	"	1	37.8
6,250	70	"	1	34
318	5	"	1	42.5
393	20	"	1	20
2,747	20	"	1	66.6
1,284	30	"	1	20.7
2,960	50	"	1	32.4
208	10	"	1	18.5
59,133	415	"	13	21
536,598	1,931		41	Total
41,276	148.5		3 1	48.1 Average

Hoisting and Conveying

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
8,333	219	Group	12	31.9
862	57	"	5	9
666	36	"	5	9.3
129	2	"	1	32.8
4,539	38.5	"	9	60.5
14,529	352.5		32	Total
2,905	70.5		6.4	28.3 Average

Hoisting and Conveying

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
16,413	471.5	Individual	16	17
7,944	380	"	16	10
8,000	560	"	71	8.6
7,586	197	"	15	10.6
5,400	194	"	15	6.7
2,547	50	"	5	25
8,448	317	"	30	13
258	10	"	1	11.5
2,466	103.5	"	12	15.3
59,062	2,283		181	Total
6,562	253		20	13 Average

Ice Cream

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
295	79	Group	10	4.8
508	52	Individual	15	5.9
1,914	56	Group	8	20
208	5	"	1	70
416	5	"	1	86
509	5	"	1	52.2
333	15	"	1	12.3
4,183	217		37	Total
596	31		5.4	35.9 Average

Ice Machines and Refrigeration

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,125	21	Group	4	29.6
645	15	"	2	24
7,032	30	Individual	2	86.8
1,389	5	"	2	96.4
2,597	17	"	2	68
6,000	147	"	10	20.7
789	2	Group	1	52.6
8,333	25	"	1	74
274	5	"	1	28
4,081	32.5	"	3	70
1,686	28	Individual	2	36.5
566	10	Group	1	32
1,600	23	"	3	32.8
1,620	20.5	"	3	70.5
9,000	137	Individual	1	69
3,541	30	"	1	55
28,700	77	"	5	57
78,978	625		44	Total
4,645	36.7		2.5	53.4 Average

Jewelry Manufacturing

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
734	12	Group	1	35.2
738	16	"	10	26
10,131	86	"	17	65.5
520	17	"	3	15.4
507	27.5	"	2	16
12,630	158.5		23	Total
2,526	31.7		4.6	31.6 Average

Laundries

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
300	5	Group	1	26.9
702	24.5	"	7	17.4
266	10	"	1	13.6
440	5	"	1	51
180	8	"	2	12
625	5	"	2	64.1
1,022	10	"	1	52
2,083	10	"	1	21.4
1,000	7	"	2	87
705	6	"	3	75.2
266	5	"	1	27.3
460	7.5	"	1	37.2
406	10	"	1	20.9
138	5	"	2	16.7
237	5	"	1	21
259	5	"	1	23
320	22.5	"	4	33.3
509	17.5	"	3	16.7
1,930	37.5	"	5	29
12,848	205.5		40	Total
676	10.8		2.1	34. Average

Marble-finishing

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,250	7.5	Group	1	89
4,000	35	"	1	68.4
1,913	35	"	2	30.3
414	17.5	"	1	18.8
377	5	"	1	45
1,008	7.5	"	1	89.5
585	8	"	1	43.3
2,199	40	"	2	35.2
4,625	60	"	3	41
522	7.5	Individual	1	37
580	10	"	1	35
100	5	"	1	84
17,573	238		16	Total
1,464	19.8		1.3	51.3 Average

Machine Shops

820	16	Group	4	34.1
5,812	106.5	"	13	27.9
166	5	"	1	17.8
384	5	"	1	40.8
3,247	39	"	6	43.5
480	25	"	1	10.2
187	6	"	1	18.5
3,285	50	"	1	34.9
3,400	123	"	9	14.7
1,546	30	"	3	27.5
5,076	219	"	25	13.9
2,278	24	"	1	48.6
1,004	20	"	2	26.8
662	7.5	"	1	48.1
212	7.5	"	1	18.9
1,217	15	"	2	43.3
1,264	10	"	1	67.5
250	5	"	1	26.7
3,827	27.5	"	2	74.2
702	7.5	"	1	29.3
275	5	"	1	29.3
2,238	15	"	1	76.5
1,183	10	"	1	60.7
1,361	10	"	1	70
348	7.5	"	1	28
41,345	350	"	13	62.8
28,098	384	"	29	40.8
4,424	60	"	16	45
4,573	104	"	5	22
700	10	"	3	38.4
217	5	"	1	24.1
1,904	30	"	1	32
1,835	40	"	1	23
694	15	"	1	24
300	10	"	1	15
270	12.5	"	2	12.3
860	26	"	2	24.5
700	23	"	6	15

MACHINE SHOPS—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
685	20	Group	1	18.3
4,140	82.5	"	5	26.8
28,452	342.5	"	12	44.3
333	7.5	"	1	23.7
683	10	"	1	36
2,916	30	"	1	51.6
2,680	62.5	"	5	24
9,274	147.5	"	11	25.1
9,471	108.5	"	15	59
1,000	14.5	"	4	49
10,482	160	"	5	38
10,300	115	"	6	51
356	7.5	"	1	26.5
416	22.5	Individual	2	9
208,332	2,996		234	Total
4,006	57.6		4.5	34.4 Average

NEWSPAPERS

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
817	25.5	Group	1	34
1,663	58	"	6	19
6,548	48	"	10	88
1,666	20	"	5	03.5
833	12	"	4	22.2
255	10	"	1	13
4,586	57	"	4	39.7
29,913	152	"	7	72
2,229	45	"	3	20
1,411	57	"	12	15.2
805	15	"	2	59.6
1,717	15	"	1	63.5
528	10	"	1	29.4
1,906	39.5	"	8	26.2
211	16	"	4	67.8
750	15	"	2	33.6
925	15	"	2	37.4
1,710	58	"	6	16.3
3,830	68	"	7	19.2
358	10	"	2	23.9
1,310	20	"	2	40
1,966	60	"	4	20
1,154	31	"	4	40
9,726	282	"	19	44.4
76,617	1,137		117	Total
3,150	47.4		4.8	38 Average

NEWSPAPERS

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,484	92.5	Individual	7	8.8
3,750	144	"	22	9
1,490	72	"	4	18.4
860	16	"	9	29.8
503	25	"	6	11.2
2,514	83	"	14	16.8
9,614	363	"	46	14.7
2,800	70	"	2	21.3

NEWSPAPERS—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,600	87.5	Individual	3	10
1,200	52	"	16	12.3
461	25	"	5	24.6
3,914	125	"	15	13.9
1,063	150	"	20	9.5
2,416	62.5	"	20	19.8
1,291	27.5	"	4	28
320	10	"	4	16.5
3,581	74	"	20	13
25,411	334.5	"	14	14.7
3,873	136	"	4	6
2,825	107	"	11	12
33,320	832	"	118	7.4
104,490	2,888.5		364	Total
4,975	137		17.3	15.1 Average

ORNAMENTAL IRON WORKS

278	3	Group	1	86.8
329	10	"	1	43.8
580	10	"	1	35
348	7.5	"	1	28
1,226	20	"	3	34.8
8,105	110	"	5	37
350	11	"	6	32.8
6,846	102	"	7	23.5
6,881	72	"	8	53
24,943	345.5		33	Total
2,771	38.4		3.6	41.6 Average

PAINT MANUFACTURING

425	15	Group	1	18.2
593	23	"	2	15.6
3,000	40	"	2	40
293	10	"	1	19.5
2,063	40	"	3	27.5
2,840	73	"	7	23.5
5,286	125	"	6	23.4
2,021	70	"	5	17.4
1,561	20	"	1	40
1,200	15	"	1	41
11,674	253.5	Individual	22	26
30,959	664.5		51	Total
2,814	60.4		4.6	26.5 Average

PRINTERS AND BOOKBINDERS

600	22.25	Individual	4	14.4
1,000	37	"	9	14.9
300	19	"	7	9.4
890	11	"	6	42
595	80.5	"	33	26.5

PRINTERS AND BOOKBINDERS—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
191	5	Individual	4	25.2
632	21	"	4	16
173	4	"	3	26.2
780	22	"	3	21.6
3,205	60	"	15	34
956	20	"	7	29
19,000	328	"	134	32
2,717	65.5	"	20	25
6,924	171.5	"	104	23
2,315	51	"	9	25.2
536	16	"	4	18.6
2,713	95	"	13	15.8
10,820	463.5	"	96	12.9
236	6	"	3	26.3
1,505	24.5	"	12	40.8
123,519	124	"	36	19.5
936	19	"	6	32.8
457	12	"	8	25.2
576	16.5	"	6	24
1,028	42	"	25	14.8
5,018	76.5	"	34	38
4,396	73	"	32	30
3,118	58.75	"	36	40
7,778	108	"	45	20
2,764	46	"	30	36
232	5.25	"	9	24.8
1,121	20.25	"	12	34
2,028	51	"	16	24
2,849	60	"	35	27
186	3.5	"	3	31
2,465	30	"	16	24
511	8	"	6	36
13,827	580	"	22	24
14,004	141.5	"	46	26
242,403	2,998		912	Total
6,215	76.8		24	26 Average

PRINTERS AND BOOKBINDERS

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
666	5	Group	1	71
1,000	10	"	1	53.3
833	9.5	"	4	53.7
400	5	"	1	42.5
266	12	"	1	11.8
300	10	"	1	16
541	10	"	1	27.8
482	5	"	1	45
458	6	"	1	45
1,528	30	"	4	38
660	9	"	4	48.8
370	6	"	2	31.6
150	3	"	1	25.6
2,970	119	"	8	15.2
2,250	15	"	1	90
1,260	32	"	7	21

PRINTERS AND BOOKBINDERS—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
177	5	Group	1	59.5
1,250	14.5	"	5	43.4
500	8	"	3	47.8
4,062	43	"	9	62.8
2,525	55	"	7	26
3,058	62	"	11	47.6
2,275	29	"	6	49.7
810	10	"	1	44
410	10	"	1	23.8
3,081	35	"	3	49
676	10	"	1	37.5
2,300	30	"	1	42.5
1,751	36	"	5	30
734	15.5	"	1	31.5
471	7.5	"	1	31.4
620	30	"	4	13.7
495	12	"	1	27.4
650	7.5	"	1	57.7
973	15	"	2	39
260	5.5	"	2	23.5
387	5	"	1	43
809	15	"	1	30
526	7.5	"	1	39
3,200	70	"	3	25.3
1,583	16	"	1	55
1,310	25	"	2	29
273	5	"	1	36.4
972	11	"	3	57.4
590	7.5	"	1	52.3
1,340	18	"	3	38
3,391	18	"	4	96
922	25	"	2	22.3
500	19.5	"	2	14.2
366	5	"	1	42.7
1,780	50	"	4	23.7
361	8	"	3	26
1,913	60	"	2	52.8
506	10.5	"	2	27
61,940	1,103		142	Total
1,147	20.4		2.6	39.5 Average

PLUMBING AND PIPE-FITTING MANUFACTURING

234	10	Group	1	31.3
274	5	"	1	36.6
356	35	"	3	5.7
634	18.5	"	6	19.8
210	15	"	2	8.5
563	20	"	3	17
1,597	65	"	3	12.6
583	12	"	3	43.2
333	12	"	1	14.8
1,049	39	"	6	27.5
18,006	63	"	8	11.1
170	5	"	1	18.8

Plumbing and Pipe-fitting Manufacturing—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
526	22.5	Group	3	13
11,481	167.5	"	20	38
9,274	147.5	"	11	25.1
45,290	637		72	Total
3,020	42.4		4.8	21.5 Average

Rubber Manufacturing

1,580	43	Individual	29	20.4
523	10	Group	1	29
2,103	53		30	Total
1,051	26		15	24.7 Average

Sheet-metal Manufacturing

1,355	39.5	Group	8	22.5
125	6	"	2	11
775	15	"	1	30
1,042	10	"	1	53
753	20	"	2	38
237	8	"	2	15.2
6,550	205	"	8	15.9
1,688	15	"	1	87
397	5	"	1	44
2,406	96.5	"	10	13.8
1,590	45	"	3	18.8
1,448	35	"	6	20.4
750	21	"	2	19
337	6	"	2	32
1,082	27.5	"	4	20
562	42.5	"	5	9
1,373	64	"	6	15
22,470	661		64	Total
1,321	38.8		3.7	27.3 Average

Soap Manufacturing

6,263	136	Group	18	25.6
666	10	"	2	29.7
6,929	146		20	Total
3,434	73		10	27.6 Average

Seeds

1,888	27.5	Group	3	41
1,162	30	"	1	21.4
1,077	30	"	3	26
566	15	"	1	20
9,893	173	Individual	21	25
14,586	275.5		29	Total
2,917	55.1		5.8	25.4 Average

Structural Steel

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
3.333	208	Individual	14	9
1.377	46	"	5	18
8,276	210	"	24	22
2,511	159	"	21	10
754	20	"	1	22
22,834	415	"	32	30
39,085	1,058		97	Total
6.514	176		16.1	18.5 Average

Structural Steel

583	10	Group	2	26
3.516	40	"	3	52.2
721	10.5	"	6	35
1,365	40	"	3	20.8
454.950	3,000	"	185	30
5,090	212.5	"	15	23
466,225	3,313		214	Total
77.704	552.1		35.6	31.1 Average

Spice Mills and Wholesale Groceries

4.968	90.3	Group	6	30
230	5	"	1	24
524	28.5	Individual	5	18
446	15	Group	1	25.5
852	26	"	4	19.8
152	7.5	Individual	3	12.2
1,408	18	Group	4	47.4
5.275	171.5	"	10	19.5
1,109	20	"	1	29
330	10	"	1	18.8
666	25	"	1	13.6
1,333	25	"	1	27.2
894	37.5	"	11	24.5
2,500	39	"	9	34.1
1,700	39	"	4	25
7,080	170	"	12	25
4,623	72.5	"	4	32.8
34,000	799.8		78	Total
2,005	47		4.5	26 Average

Stone-cutting

109	7.5	Individual	1	19.4
25,000	300	Group	20	53.4
2,532	50	Individual	6	30
2,411	31	Group	2	47
98,381	685	"	23	85
1,282	15	"	1	77.3
440	5	"	1	54.2
2,260	45	"	3	27.9
697	20	"	1	17
3.325	90	"	3	19

STONE-CUTTING—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
1,060	30	Group	1	18
464	10	"	1	25.7
257	10	"	1	14.2
1,108	15	"	1	41
333	20	Individual	1	8.8
918	30	Group	1	17.3
1,375	15	"	1	52.3
2,436	80	"	2	16
3,654	55	"	3	50
465	17.5	"	3	15
148,507	1,531		76	Total
7,425	76.5		3.8	34.4 Average

TANNERIES

666	8	Group	2	61.8
2,657	35	"	3	42.2
1,412	20.5	"	4	38
2,701	20	"	2	90
4,903	60	"	2	41.1
12,339	143.5		13	Total
2,466	28.6		2.6	54.6 Average

TOBACCO MANUFACTURING

1,288	15	Group	1	47.7
1,000	10	"	3	53.5
450	30	"	1	9
11,026	194.5	"	23	29
13,764	249.5		28	Total
3,441	62.3		7	37.5 Average

WOOD-WORKING

600	10	Group	1	30.8
300	10	"	1	20
300	5	"	1	30.8
676	10	"	1	33
1,764	70	"	7	14.5
2,676	46	"	9	33.3
492	22.5	"	3	24.5
4,391	63	"	8	42.2
600	25	"	5	25
2,841	35	"	4	45
369	10	"	4	18.8
976	22.5	"	1	26.6
2,900	20	"	1	79
483	15	"	1	21.5
3,070	82	"	5	22.2
7,956	67.5	"	2	67
1,585	47.5	"	4	17.8
1,380	20	"	1	36.8
1,583	57.5	"	3	14.2
208	7.5	"	1	15.8
1,666	25	"	4	44.5
1,215	15	"	1	56.8
9,200	82.5	"	5	59.8

WOOD-WORKING—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
2,270	37.5	Group	1	31
765	16	"	2	29
586	15	"	1	27.4
40,695	364	"	28	64.5
1,296	25	"	2	26.5
4,424	90	"	5	27
1,333	30	"	1	23.7
1,333	10	"	1	71.2
600	15	"	1	20.5
1,606	35	"	2	30.6
993	15	"	1	44.2
841	15	"	1	38.8
840	12	"	1	46.6
305	25	"	1	72.4
967	15	"	1	38.2
900	20	"	1	23
1,333	10	"	1	70
1,750	30	"	4	30
1,502	25	"	2	34
135	5	"	1	14.4
193	7.5	"	1	14.7
225	5	"	1	60
132	5	"	1	35.2
156	7.5	"	1	27.8
1,436	60.5	Individual	9	14.3
4,994	125	"	18	24
1,508	68	Group	7	13
4,000	40	"	1	51
772	15	"	1	28.6
2,700	125	"	10	11
150	5	"	1	40
356	10	"	1	47.7
900	25	"	1	24
977	15	"	1	34.8
1,750	30	"	4	30
1,000	25	"	1	20.4
750	30	"	1	13.4
2,620	100	Individual	14	16
2,690	81	"	15	19
3,046	64.5	"	7	31
5,560	110	Group	7	28
147,620	2,532		234	Total
2,306	39.5		3.6	33.3 Average

WOOLEN MILLS

20,985	150	Group	3	71

GRAND TOTALS

Total kilowatt-hours per month	3,329,298
Average kilowatt-hours per month per consumer	3,500
Number of consumers	951
Total horse-power connected	54,541
Total number of motors	5,785
Average number of motors per consumer	6.08
Grand average load . . . per cent,	33.9

Referring to the above tables you will notice that there is a considerable difference in the average kw-hour consumption in the plant driven by individual motors as against the plant run by a group-drive installation. The difference in the average load for these two classes of drive will not indicate the exact difference in the consumption of current for a given factory, owing to the fact that the group-drive installation would probably be in the neighborhood of 80 per cent of the individual-motor connected load. If an individual installation were made there would, however, be a saving that would a great deal more than offset the interest on the investment in the extra cost of motors for such an installation, and a close study of the above figures should convince us that wherever possible the use of a number of motors is preferable to the use of a few. Having seen very few of the motor installations in other cities, it is impossible to draw exact conclusions from the above figures. The following table gives a list of installations of two large companies in one city with which I am familiar, and you will notice in comparing the averages of this table with those of the previous one, that they are very similar. The figures in this table were compiled very carefully and in some cases the current consumption for a period of two years was taken into consideration.

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
		Brass Beds		
3,327	28.5	Group	12	32.3
		Butchers and Packers		
640	20	Individual	1	19
1,518	51.5	"	9	17
		Bakeries		
5,800	60	Group	3	20
1,099	20	"	1	33
		Box Manufacturing		
6,086	94.5	Group	54	37
		Boots and Shoes		
436	6	Group	1	43
4,525	45	"	14	51
		Can Manufacturing		
1,400	23	Group	4	74
5,234	60.5	"	8	49

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
		Carpet-cleaning		
1,126	15	Group	1	43
		Chemical Works		
1,189	40	Group	7	21
		Candy Manufacturing Companies		
800	18	Group	3	30
3,316	65	"	12	29
2,376	83	Individual	27	26
		Clothing		
485	12.5	Group	7	22.1
1,736	21.5	"	18	49
		Engraving and Stereotyping		
938	30	Individual	23	15
1,415	39	"	25	23
10,927	162	"	91	40
		Foundries		
2,490	56	Individual	5	23
2,511	159	"	21	10
1,663	80	"	4	14
2,665	38	Group	5	38
3,305	88	Individual	13	21
5,397	85	"	10	36
756	22.5	"	3	20
		Feather Cleaners		
1,697	35	Group	1	27.5
3,197	73.75	Individual	10	24
		Glass-grinding and Beveling		
5,795	64.5	Group	10	50
		General Manufacturing		
1,982	75	Individual	11	15.1
10,291	197	"	43	21
326	5	"	4	40
3,600	83	Group	8	23
810	29	"	5	20
1,462	34	"	10	25
3,485	67	Individual	27	30
11,604	250	Group	5	30
1,586	26	"	11	36.8
436	39	"	8	17
6,640	82.5	"	11	44
3,000	85	"	3	20
200	5	"	2	24
200	5	"	1	24

General Manufacturing—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
9,893	173	Individual	21	25
2,929	60	"	28	28
45,624	225	Group	8	44
2,861	76.5	"	12	21
13,100	95	"	6	52
		Hoisting and Conveying		
16,413	471.5	Individual	16	17
7,944	380	"	16	10
		Ice Machines		
9,000	137	Individual	1	69
3,541	30	"	1	55
28,700	77	"	5	57
		Jewelry Manufacturing		
734	12	Group	1	35.2
		Marble-finishing		
4,625	60	Group	3	41
		Laundry		
1,930	37.25	Group	5	29
		Machine Shops		
2,680	62.5	Group	5	24
9,274	147.5	"	11	25.1
9,471	108.5	"	15	59
1,000	14.5	"	4	49
10,482	160	"		38
10,300	115	"	6	51
		Newspapers		
25,411	334.5	Individual	14	14.7
3,873	136	"	4	6
2,825	107	"	11	12
33,320	832	"	118	7.4
		Ornamental Iron		
6,881	72	Group	8	53
		Paint Manufacturing		
11,674	253.5	Individual	22	26
		Printers		
5,018	76.5	Individual	34	38
4,396	73	"	32	30
3,118	58.75	"	36	40
3,642	108	"	45	20
2,764	46	"	30	36

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PRINTERS—*Continued*

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
232	5.25	Individual	9	24.8
1,121	20.25	"	12	34
2,028	51	"	16	24
2,849	60	"	35	27
186	3.5	"	3	31
506	10.5	Group	2	27
2,465	30	Individual	16	24
511	8	"	6	36
13,827	580	"	22	24
14,004	141.5	"	46	26
		PIPE AND PLUMBERS' FITTINGS		
11,481	167.5	Group	20	38
9,274	147.5	"	11	25.1
		SHEET-METAL MANUFACTURING		
1,355	39.5	Group	8	22.5
125	6	"	2	11
562	42.5	Individual	5	9
1,373	64	"	6	15
		SEEDS		
1,888	27.5	Group	3	41
9,893	173	Individual	21	25
		SPICES MANUFACTURING AND GROCERS		
4,968	90.3	Group	6	30
524	28.5	Individual	5	18
1,700	39	Group	4	25
7,080	170	"	12	25
4,623	72.5	"	4	32.8
		STRUCTURAL STEEL		
5,090	212.5	Group	15	23
2,511	159	Individual	21	10
22,834	415	"	32	30
8,276	210	"	24	22
754	20	Group	1	22
		STONE-CUTTING		
465	17.5	Group	3	15
		TYPE-FOUNDERS		
1,516	27	Group	4	55
		TOBACCO MANUFACTURING		
450	30	Group	1	9
11,026	194.5	"	23	29
		WOOD-WORKING		
2,620	100	Individual	14	16
2,690	81	"	15	19
3,046	64.5	"	7	31

Wagon Manufacturing

K. W. H. per Month	Connected Motor Load in H. P.	Individual or Group Drive	Number of Motors	Percentage of Average Load to Connected Motor Load
567	20	Individual	6	18

Totals of 110 Consumers as Shown Above

				Per Cent
580,950	10,627.5		1,512	30.3 Total
5,281	96.6		13.7	30.3 Average

Individual Drive—54 Consumers

281,958	6,608		1,078	Total
5,221	122.3		20	22.9 Average

Group Drive—56 Consumers

298,992	4,019		434	Total
5,339	71.8		8	33 Average

The following is a statement showing the number of companies communicated with and those heard from, together with the portion sending usable information. You will notice that there were 190 companies not heard from in any way. If we are to have this information compiled in a thorough manner in future it is necessary to hear from all companies that have a power load. A great many of the larger companies have sent no information, for one reason or another. This accounts for the small connected horse-power load in the general table of power information. The compiling of similar data at some future day, when the number of customers for each class of business is larger, will be more accurate than the present information, and I would suggest that this subject be thoroughly investigated, as such information can be made of great value to central-station companies in acquiring new business.

Companies communicated with	458
" heard from	269
" not heard from	190
" sending power data	99
" " usable data	75
" stating they had no power data	127

Respectfully submitted,

E. W. Lloyd, Reporter.

THE PRESIDENT: Gentlemen, this report is open for discussion.

MR. DUNHAM: There is an element in the report that has been overlooked. Our largest user of power is the firm of Pratt and Whitney. We sell them 650 horse-power. They asked me to make a certain price, and brought down a ream of paper and showed what it cost to make this power in three large establishments where they ran generators by steam and had motors scattered all over the factory. You must compete with that. You can not base your ideas on motors simply, because they pay for the motors and can put in steam engines direct-connected to the generator, to make their own current, as well as the central station can. An element comes in there which will be overlooked unless you have put out a very large amount of power for a small place. We find that on 5000 horse-power of motors installed, we delivered from the switchboard about 40 per cent; that is to say, the averages of the power all through the town will run a good deal less than the total input of motors. I think that is where the profit comes in. You figure that you are selling a certain horse-power, and you are not delivering it. Our price is based on nine hours' use, and we escape the peak except for two months in the year. They stop at five o'clock all the year round. Perhaps for two months there is a small peak, which we supply by storage battery.

THE PRESIDENT: I want to call the attention of the members to a feature of this subject that has struck me as being of peculiar value to such members as have not yet undertaken the furnishing of electric power to factories. This report was to be put in such shape that if any application were made for business a reference to it would give the central-station manager an approximate estimate of the relation between the average load and the connected load. When this paper was first spoken of there was a great question as to whether or not the figures finally obtained would justify a reasonable belief that the averages could be properly applied by a central station not able to go to the expense of employing educated engineers. I am sure Mr. Lloyd would point out, if he were here, that the averages in the paper will constitute a good basis upon which an estimate can be made by a central-station manager having very

little practical knowledge of the business for which the power is contracted. I should like to hear this phase of the subject amplified. Unfortunately, the use of power in my town is not sufficiently large to justify any further remarks on my part.

MR. GILLE: There is one point in the report that should be emphasized, and that is where it is shown that isolated plants are obliged to run during winter-time to get sufficient steam to heat their buildings and are not required to have the steam in the summer-time. I think a considerable revenue can be derived from getting the business in the summer-time that can not be obtained on a profitable basis in the winter.

MR. EGLIN: In reference to the tables given in Mr. Lloyd's paper, I had the pleasure of reading the paper previous to the meeting and was not inclined to agree with the arrangement of the tables of the average results. In the case of a machine shop or a single class of work, he takes the average of the total number, and if you look through this paper you will find one or two machine shops with 600 horse-power and then a large list with five, ten and fifteen horse-power. The average horse-power for machine shops might be somewhat misleading, in view of the fact that the one or two cases will raise the average; especially so, I think, if these tables should be generally used. On the other hand, the case is so evident that it will be easy to correct these averages for persons desiring that information; so I feel that perhaps Mr. Lloyd had no recourse but to make the averages as he did in the tables. I feel that the association has received in this report just the kind of information that is wanted by the members, and we are indebted to Mr. Lloyd for the able way in which he has presented it to us and for the large amount of data he has placed at our disposal.

MR. EMERICK: Information is desired of cases where a proposition has been made involving power furnished a concern whose by-products are available in the way of fuel, such as sawdust, shavings, buckwheat shucks, or anything of a similar nature. We had one case—that of a buckwheat mill turning out large quantities of buckwheat shucks, ordinarily used for fuel and possessing considerable value for that purpose. This particular plant runs for about five months in the year, 24 hours a day, making enough shucks to furnish the fuel it requires. In order to become acquainted with the facts in this and similar

cases, I spent a couple of days in looking up plants of the same kind, and found that, contrary to my first belief, the shucks had a decided fuel value. The situation was a difficult one to handle, as the plant requires some steam for drying purposes as well as for heating. After considerable time spent on the proposition, we finally worked out a plan whereby we allowed a rate that appeared to them quite low, and, in fact, was low for power to be furnished during 18 hours. We dictate the daily period each month, thereby relieving ourselves of a load of this kind during the peak, and enabling us to control the demand in a way that satisfies both the customer and the central-station conditions.

Mr. Gilchrist: I wish to emphasize one point brought up by Mr. Lloyd, which I think is of great importance to all the companies, and that is discountenancing the practice of attempting, without sufficient investigation, to get business by cutting rates. Mr. Lloyd has shown quite conclusively that the average plant now running from steam engines is improperly designed, and by good engineering a great economy can be obtained, which can be laid to the credit of the electrical installation if the man in charge of the deal is clever enough to take advantage of it. Some economy undoubtedly might be obtained by a redesigning of the customer's steam plant. Many times by nursing a man along and educating him he can be worked up to a place where he will pay a much higher price than on the first estimates you can make him believe will be advantageous to him, and then when you get him you can convince him of the truth of your argument that even at that higher price it is a more economical proposition for him.

I can cite one case that will give an answer to the question raised by Mr. Emerick. We had the case of a concern that manufactured coffins. They used probably 150 to 175 horsepower. They had operated by steam and had a great deal of hard-wood sawdust, shavings and chips (which are not so marketable as soft-wood shavings) as refuse, which they used for generating steam. We worked on them a long time, and the lowest rate we wanted to quote was 4.5 cents per kilowatt-hour. They showed us that they could not afford to pay more than 2.5 to three cents per kilowatt-hour. We argued that their average load would be nothing like so large as they thought it would be and that their bills, instead of being $250 per month at 2.5 to

three cents per kilowatt-hour, would not be over $150 to $175 at 4.5 cents per kilowatt-hour. We finally induced them to put in a kiln for drying their lumber, which was done by using the refuse as fuel, and then by making them a maximum guarantee for a period of one year of $2.00 per horse-power installed, with the definite understanding that it was merely a test and that we would not consider such a proposition for more than one year, but that at the end of the year they must go on the meter rate, we signed them up. The results were favorable, and they have never had a bill over $175.

I believe it is a debt we owe to the association and to ourselves to attempt to keep the rates as high as is fair to be charged. I do not mean by that to attempt to force rates above what is fair, because such a policy will undoubtedly react, and react seriously; but merely to avoid being stampeded into making rates based on special installations which are lower than we can afford to make generally.

Mr. Eglin has surmised Mr. Lloyd's idea in the matter of these averages. He figures that while the average, taking the case of machine shops, runs from 12 per cent of the connected to 70-odd per cent of the connected, to strike an average of, say, 40 per cent would furnish no criterion, but would at least give you this advantage that you could say to a man that there would be no use in considering single motors, because he was going to put in several motors. Take all the installations that have, say, four motors or more, and you will find that the highest average is 62 per cent and the lowest average is 40 per cent. You are going to get something between 40 per cent and 62 per cent, in all probability, because here is a fair number of cases. So, if we start on the assumption that you will have an average as high as the highest, we insist on your taking that as the starting point, and insist that you figure on your average and not on your connected load throughout your running hours.

The President: From now on the business of the convention will be considered in executive session.

EXECUTIVE SESSION

REPORT OF THE COMMITTEE ON AMENDMENTS TO THE CONSTITUTION

THE PRESIDENT: We will now have the report of the committee on amendments. The amendments have been handed to the secretary by the committee, consisting of Mr. Henry L. Doherty, chairman; Mr. H. T. Hartman and Mr. G. W. Brine. The secretary will read the amendments.

The following amendment to the by-laws was read by Secretary Farrand:

Amend Section 3, Article IV, to read as follows: *The vice-presidents of this association shall be members of the executive committee, and the retiring president shall, by reason thereof, be a member of the executive committee for the period of one year after the expiration of his term.*

On motion, the amendment was unanimously adopted.

Secretary Farrand then read the following amendment:

Amend Article VIII by inserting the following matter before the words, "All officers, etc.": *At an executive session to be held on the second day of the annual convention, there shall be chosen a nominating committee, to be composed of five accredited representatives from member companies Class A, in the following manner:*

Any accredited representative of a member company Class A, shall have the privilege of making nominations, and when such nominations are seconded by any other such accredited representative, that nominee shall be one of those to be voted for. Nominations in this manner may continue until a resolution shall be adopted to close the lists. After the lists are closed, a ballot shall then be taken. The accredited representative present of any Class A member company shall have the right of voting for five of those placed in nomination in the manner previously described. The five nominees receiving the highest number of votes shall constitute the nominating committee.

This nominating committee shall, at a subsequent executive session, bring in the names of those recommended by them for the several offices to be filled.

The submission of names by the nominating committee shall not, however, debar any accredited representative of a Class A member company from making nominations for any or all of the several offices to be filled, which nominations, if seconded, shall be submitted for election at the same time and in the same manner as those of the nominating committee. Whenever there are more nominees than vacancies to be filled, then, in such cases, the election shall be decided by ballot. When there is no contest for any office, the secretary may be instructed by a viva voce *vote to cast the ballot for those recommended by the nominating committee.*

(On motion, the amendment was unanimously adopted.)

REPORT OF THE COMMITTEE ON NOMINATIONS

THE PRESIDENT: We will now hear the report of the committee on nominations.

MR. LOUIS A. FERGUSON: Mr. President, the committee on nominations desires to make the following report:

For president, William H. Blood, Jr., of Seattle, Wash.

For first vice-president, Arthur Williams, of New York City.

For second vice-president, Dudley Farrand, of Newark, N. J.

For three members of the executive committee, to serve for three conventions: Charles L. Edgar, of Boston; John Martin, of San Francisco; Frank W. Frueauff, of Denver.

Respectfully submitted,

Committee,
LOUIS A. FERGUSON, Chairman,
PAUL DOTY,
PAUL SPENCER,
N. F. BRADY,
SAMUEL SCOVIL.

THE PRESIDENT: Gentlemen, you have heard the report of the committee on nominations; what is your pleasure?

MR. ABELL: I move that the secretary be empowered to cast the ballot of the members present for the unanimous election of the members nominated.

(The motion was seconded and carried.)

MR. FERGUSON: Before the ballot is cast, I would say that the reason why the committee on nominations did not name a nominee

for the office of secretary-treasurer is because the by-laws state that the secretary and treasurer shall be nominated by the president and confirmed by the executive committee. This practice, however, has not been followed for the past two years. Last year the present secretary, Mr. Dudley Farrand, was elected by the convention, and I think that inasmuch as the secretary-treasurer is no longer a paid officer it would be a very complimentary thing to elect a gentleman by the convention at the same time that the other officers are elected, and I would say that it is the sense of the committee on nominations that the new secretary-treasurer should be Mr. W. C. L. Eglin, of Philadelphia.

(The secretary cast the ballot and the president declared the nominees unanimously elected.)

Mr. Ferguson: In view of what I have just said, I move that the executive committee be recommended to select as secretary-treasurer Mr. W. C. L. Eglin, of Philadelphia.

(The motion was seconded and carried.)

The President: Gentlemen, I have pleasure in presenting to you Mr. Blood, your new president. I can only bespeak for him the same kind consideration that has been accorded me. I believe he will receive during his administration the hearty support of all our members.

Let me say a few words for myself. I am the representative of a small company, and I was unexpectedly elected to the presidency of this association, as Mr. Blood has been on this occasion, and the importance of the position impressed me very much. I believe that few of our members appreciate the great influence of the association and the fact that we are making history, whether we act or whether we do not act. I have been trained as a lawyer and drifted into this business, and what has struck me forcibly, as I stated in my address, is the great danger to the industry of unwise legislation.

I take great pleasure in introducing Mr. Blood.

Mr. Blood: Mr President and Gentlemen—It is said that there is no state in the country where the lightning comes out of a clear sky as it does here in Colorado. This time it certainly came out of a clear sky as it struck me. The honor is entirely unexpected, and I hardly know what to say. I appreciate it very highly. I realize my own shortcomings, and also realize that the

only way I can make a success in holding so high an office in this association is through your hearty co-operation, and I ask that I may receive from you the same assistance that you have given to your presidents in the past.

A few years ago this association was put on a very high plane, and I think that to-day it ranks as high as any organization of the kind in the country. I hope nothing may happen during the coming year to lower in any way the high standard we have attained as an association; but I can succeed in my work here only with your hearty co-operation. I thank you most cordially for the honor you have conferred upon me in electing me president of so important an organization.

THE PRESIDENT: Gentlemen, we will now have the report of the committee on the president's address. Mr. Louis A. Ferguson is chairman of that committee.

The following report was presented by Mr. Ferguson:

REPORT OF THE COMMITTEE ON THE PRESIDENT'S ADDRESS

Mr. President and Gentlemen: Your committee agrees most fully in the position taken by our esteemed president regarding the matter of unwise and restrictive legislation, as expressed in the following paragraph of his address:

"The one great and constant menace to the industry is unwise, burdensome and restrictive legislation by the municipality and the state. The right to tax is the power to destroy. The power to regulate contains the germ of the danger of confiscation, in whole or in part. The regulation of the industry by a commission with powers such as are vested in the Gas and Electric Light Commission of the state of Massachusetts, may be proper and satisfactory as safeguarding both the rights of the public and of the investor. But regulation by a commission brought into being by a manufactured public sentiment, and having its inception in politics, and not primarily or honestly intended to remedy any admitted public oppression or to properly regulate the use of public franchises, can not be fair either to the public or to the investor, and must result in gross injustice to the industry.

"The association should not be passive while laws placing the industry under the regulation of commissions are passed

by the several states, without making proper suggestions whereby such laws would be made reasonable and uniform in their provisions. Nor should it permit, without protest, the passage of any laws admittedly unduly restrictive and burdensome. The object should be to have the general laws of the several states, relating to the industry, conform to some standard fair both to the public and to the industry.

"For one state to grant only very limited term franchises under burdensome restrictions, and for another—and possibly an adjoining state—to grant perpetual franchises without restrictions; for one state to reserve the right to fix and change the rate of charge for service rendered, and for another state to empower any municipality to make any rate it may see fit, and to change the same when and as it pleases, can not but injuriously affect the stability of the industry from the standpoint of the investing public.

"I would, therefore, recommend the appointment of a standing committee on legislation to aid in protecting the interests of our members should occasion arise."

We endorse the recommendation of the president as to the appointment of a standing committee on legislation, but in the time at our disposal we do not feel that we are prepared to recommend a definite method of procedure in this respect. We would recommend, however, that this very important and pressing matter be given immediate and full consideration by the executive committee.

We most heartily approve the suggestion of our president for the encouragement of state and sectional organizations, and the co-operation of the proposed committee on legislation with those bodies.

We wish to emphasize most strongly the advice given, that by way of self-protection the central stations should more than live up to the obligations of their franchises; should furnish public lighting at reasonable prices, and serve the public so well that any agitation started for political or personal ends will not receive the support of a justly indignant public.

We would call the attention of the member companies to the growth in numbers of the membership resulting from the change in our by-laws, as shown by the figures given in the president's report, and would respectfully advise the member companies to continue to take advantage of this change.

We endorse the recommendation of the president as to the appointment of a committee to work in conjunction with the Association of Licensed Manufacturers of Incandescent Lamps, which association has appropriated the sum of $10,000 for the purpose of co-operating with the central-station companies for increasing the use of incandescent lamps.

We would especially call the attention of the incoming president to the value of continuing the policy, followed during the administration just closing, of calling frequent meetings of the executive committee, so that the president may at all times be fully in touch with the needs of the member companies, and at the same time have the benefit on all occasions of the judgment of the members of the executive committee.

We deem it highly important that the president's suggestion be carried out that the records of the work of the officers, executive and other committees, together with all the correspondence of the officers and executive committee, be filed and preserved in the headquarters of the association in New York, for reference by the new officers and committee.

All of which is respectfully submitted.

Committee, LOUIS A. FERGUSON, Chairman,
FRANK W. FRUEAUFF,
GEORGE R. STETSON,
SAMUEL SCOVIL,
S. T. CARNES.

(On motion, the report of the committee was approved.)

The following report was presented by Mr. Dudley Farrand, secretary and treasurer of the association:

REPORT OF THE TREASURER FOR THE FISCAL YEAR ENDING DECEMBER 31, 1904

January 1, 1904, cash in bank	$9,323.80	
Petty cash in hands of assistant treasurer	150.00	
		$9,473.80
RECEIPTS DURING FISCAL YEAR		
Active members' dues.........1903	$80.00	
Associate members' dues......1903	20.00	
Entrance fees active members..1904	975.00	
Active members' dues.........1904	7,426.50	
Associate members' dues......1904	2,240.00	
Active members' dues.........1905	35.00	
Associate members' dues......1905	20.00	

Advertisements in Proceedings Twenty-sixth Convention	1,205.00	
Advertisements in Proceedings Twenty-seventh Convention	935.00	
Sale of stenographic report Twenty-seventh Convention	200.00	
Sale of badges Twenty-seventh Convention	118.00	
Sale of publications	413.80	
Reprints	223.79	
		13,892.09
Total cash on hand during 1904		$23,365.89

DISBURSEMENTS DURING FISCAL YEAR

Expenses of former secretary and treasurer	$150.00	
Expenses of executive committee meetings	193.75	
Salary of assistant secretary and treasurer	2,124.93	
Office rent	671.71	
Office force	1,556.97	
General office expenses	226.30	
Office furniture	130.25	
Telephone rental and messengers	122.74	
Badges for Twenty-seventh Convention	138.14	
Expenses account World's Fair, St. Louis	299.50	
Expenses account municipal plant investigation fund	79.00	
Expenses account district steam heating fund	56.83	
Expenses account steam turbine committee	222.05	
Express and messengers	529.97	
Printing and stationery	330.02	
Printing and expenses of publications	2,650.25	
Printing Proceedings Twenty-sixth Convention	2,023.94	
Printing Proceedings Twenty-seventh Convention	4,034.06	
Postage and telegrams	674.33	
Expenses account Twenty-sixth Convention	20.00	
Expenses account Twenty-seventh Convention	549.36	
Traveling expenses	78.25	
Dues refunded	26.65	
Drafts refused	120.00	
		$17,009.00

STATEMENT OF FUND FOR EXPENSES OF COMMITTEE FOR INVESTIGATING THE PHOTOMETRIC VALUES OF ARC LAMPS

January 1, 1904	Balance on hand	$183.91	
	No receipts or expenses.		
	Balance on hand December 31, 1904		$183.91

MUNICIPAL PLANT INVESTIGATION FUND

January 1, 1904	Balance on hand	$2,759.45	
	Disbursed during 1904	79.00	
	Balance on hand December 31, 1904		$2,680.45

DISTRICT STEAM HEATING COMMITTEE FUND

January 1, 1904	Balance on hand	$191.25	
	Disbursed during 1904	56.83	
	Balance on hand December 31, 1904		$134.42

STEAM TURBINE COMMITTEE

January 1, 1904	Balance on hand	$1,000.00	
	Disbursed during 1904	222.05	
	Balance on hand December 31, 1904		$777.95

RECAPITULATION

Cash in bank, and in hands of assistant treasurer January 1, 1904		$9,473.80
Receipts during the year 1904, as per detailed list		13,892.09
		$23,365.89
Disbursements during 1904, as per detailed list		17,009.00
Total cash on hand December 31, 1904		$6,356.89
Cash in bank December 31, 1904	$6,206.89	
Cash in hands of assistant treasurer	150.00	
		$6,356.89

CASH ON HAND DECEMBER 31, IN THE VARIOUS FUNDS AND COMMITTEES

Committee for investigating the photometric values of arc lamps	183.91
Municipal plant investigation fund	2,680.45
District steam heating committee fund	134.42
Steam turbine committee	777.95
General fund	2,580.16
Total cash on hand December 31, 1904	$6,356.89

ASSETS

Cash as per statement	$6,356.89
Office furniture	583.45
	$6,940.34

LIABILITIES

None except current bills.

Respectfully submitted,

DUDLEY FARRAND, Treasurer.

To the President and Directors of the National Electric Light Association:

GENTLEMEN: I have carefully examined the books and vouchers of the treasurer of your association for the fiscal year ended January 1, 1905, and certify to the correctness of his report herewith attached.

I have further examined the accounts to and including May 15, 1905, and found all receipts and disbursements properly accounted for, and available cash in bank and office as of that date to the amount of $13,030.26.

Respectfully submitted,

C. N. JELLIFFE, Auditor.

(On motion, the report was approved and ordered to be placed on file.)

THE PRESIDENT: The next business is the preliminary draft of the report of the committee on rates and costs, Mr. Charles L. Edgar, chairman.

On motion of Mr. Williams, the report was received and its publication referred to the executive committee.

On motion, the following resolution was adopted:

WHEREAS, It is greatly to the advantage of our members to obtain as promptly as possible, and from authoritative sources, exact information concerning the characteristics and value of important developments in the electrical field; therefore be it

Resolved, That the executive officers be and hereby are authorized to expend during the fiscal year 1905-6 not to exceed five hundred dollars in procuring such electrical tests as in their judgment are advisable, from a competent testing laboratory, and report the same as promptly as possible to each member.

On motion of Mr. Samuel Scovil, the following resolution was adopted:

The attending delegates at this twenty-eighth convention of the National Electric Light Association desire to express in the most hearty manner their appreciation of the work of the several committees on arrangements in connection with this annual convention; a work that has been so well done that each person who has had the good fortune to make this visit to these two beautiful cities, situated so uniquely in the shadow, as it were, of these far-famed and imposing mountains, must carry away with him the most pleasing recollections of Denver and Colorado Springs and the citizens thereof.

To the mayor, Robert W. Speer, who so felicitously welcomed us to Denver at the opening of these proceedings, we express our most hearty thanks for his courtesy;

Also to Mr. Henry Russell Wray, the secretary of the Colorado Springs Chamber of Commerce, for his efforts to make our stay in his town one long to be remembered;

Also to all general, special and ladies' committees for their work in our behalf, and to all the local and central stations for their assistance in like matters;

Also to the railroad companies for their excellent arrangements for our comfort, and to the local press of Denver and

Colorado Springs for their excellent reports of the proceedings of this convention.

Before we came here there was doubt expressed by some of the people connected with this association as to the wisdom of coming to Denver and Colorado Springs. Results obtained are always the supreme test of ability to accomplish things. Thus judged with reference to this convention, the arrangements for its meetings, and the entertainment of its delegates, Denver and Colorado Springs, in the minds of attending delegates, must be placed at the top of the list as good places indeed for all societies holding annual meetings to convene.

The following letters were read, inviting the association to hold its next meeting at Brooklyn or at Buffalo:

To the National Electric Light Association,
Denver, Colorado.

Gentlemen: The privilege of entertaining the association at its next annual convention is requested by the Edison Electric Illuminating Company of Brooklyn, New York. Manhattan Beach, adjoining Brooklyn, is a place of high character, with large hotels, located right on the ocean, and offers exceptional accommodations for our members.

The hotels are within an hour of the heart of Manhattan Island, and the New York Edison Company would join in making the meeting memorable from every possible point of view.

We offer the advantage of a meeting centre removed from the noise and bustle of a great city, combined with all the attractions that a great city can offer. In addition to amusements of every kind and a wealth of attractions, there are no less than seven great power stations, including those of the Metropolitan Railroad Company, the Manhattan Elevated Railroad, the great station of the underground system, the present and approaching Waterside stations of the New York Edison Company, and the work of unprecedented magnitude in railroad engineering of the Pennsylvania and New York Central railroads.

Manhattan Beach is the meeting-place of the Street Railway Association during the present month—an association that requires accommodations even greater than those necessary to meet the needs of our own association.

Trusting that it may be practical to accept this invitation and confer this privilege upon us, I am

Truly yours,
Nicholas F. Brady.

Bureau of Conventions and Industries
of the
Chamber of Commerce of Buffalo

J. E. Stephenson, Chairman F. Howard Mason, Secretary

Buffalo, N. Y., May 11, 1905.

Mr. Ernest H. Davis,
136 Liberty Street, New York.

Dear Sir: We have been in communication with Mr. Charles R. Huntley, of this city, relative to securing next year's convention of the

National Electric Light Association for Buffalo, and we are advised by him to request an opinion from you concerning the advisability of making an effort to secure this much coveted honor for this city.

It is sixteen years since your organization met here, and we are assured by Mr. Huntley that he will be very glad to see the convention brought to Buffalo.

Will you kindly express your views on this subject, and greatly oblige

Very truly yours,

RICHARD C. O'KEEFE,
Assistant Secretary.

(On motion, the invitations were referred to the executive committee.)

THE PRESIDENT: We will now take up the *Question Box*, Mr. Homer E. Niesz, of Chicago, editor.

MR. NIESZ: The *Question Box* will have to speak for itself; I will simply read the introduction.

(The *Question Box* is to be found in full in Volume II of the proceedings.)

Mr. Arthur Williams presented his report on municipal ownership.

On motion of Mr. DeCamp, Mr. Williams' report was received and ordered filed as an official record for the use of the members of the association.

Mr. Arthur Williams presented the following report relating to the demise of certain members of the association:

It is with profound regret that we must record the death of two of our honorary members, George L. Bowen and Baron de Rothschild, and of four of our active members, Charles H. Peters, George W. Davenport, A. P. Goddard and Edward A. Leslie, since the close of the last convention.

To George L. Bowen may largely, if not entirely, be given the credit for the organization of this association. He might be designated the Father of the National Electric Light Association.

Baron de Rothschild was always interested in science and invention, as in art in many other directions; but his connection with the practical work of the association is not clear. Honorary membership was probably conferred upon him because of his general prominence in matters referred to, and because of his well-known and keen interest in the electrical development of this country.

Charles H. Peters was long an active member from the state in which the present convention is held. It is a matter of regret that he could not have lived to attend the first convention of the association in which he was so much interested that could be really called a western convention.

George W. Davenport, of the Niagara Falls Power Company, was most active in the association for many years. His efforts in behalf of the association in increasing interest in the meetings and the membership will long be remembered by those who were privileged to work with him.

Mr. A. P. Goddard, president of the Freeport Railway, Light and Power Company, a valued member of the National Electric Light Association, died at his home in Freeport, Ill., on Tuesday, February 12, at the age of seventy-two. He was born in Franklin County, N. Y., but his family removed to Freeport when he was two years old. Mr. Goddard was prominently identified with the development of Freeport, having served as alderman, mayor and member of the board of supervisors. He also served in the Civil War as first lieutenant in the Illinois Volunteer Infantry, and was brevetted a captain for honorable service. Mr. Goddard was a prominent Freemason.

Mr. E. A. Leslie, vice-president of the Edison Electric Illuminating Company of Brooklyn, died at his residence on Monday afternoon, June 5, as we were gathering at this convention. Mr. Leslie was born at Harrisburg, Pa., in 1849. After a varied experience in the telegraph field—as manager of the Western Union Cable Department in New York, as superintendent of the Mutual Union Telegraph Company, headquarters in Washington (1882), as superintendent of the National Telegraph Company (1884), as superintendent of the Baltimore and Ohio Telegraph Company, Western Division (1885), as general superintendent of the latter company, with headquarters in New York—he afterward became connected with the Consolidated Telegraph and Electrical Subway Company, and in 1888, became manager of the Manhattan Electric Light Company of New York, afterward consolidated with the New York Edison Company. He held this position until 1901, when he became general manager and vice-president of the Edison Electric Illuminating Company of Brooklyn. At the time of

his death he was secretary of the Association of Edison Electric Illuminating Companies and a director and treasurer of the Electrical Testing Laboratories. Mr. Leslie took a prominent part in the affairs of the association, and for some time past had been looking forward to this meeting. He was a man of many friendships and strong character and personality.

I submit this as a memorial of our deceased members.

ARTHUR WILLIAMS.

THE PRESIDENT: We will now have the report of the committee on relations with kindred organizations, Mr. James I. Ayer, chairman. Mr. Williams will read the report.

(After the reading of the report, on motion, it was accepted and referred to the incoming executive committee, to take such action on the same as might be deemed proper.)

The report of the executive committee was read by Secretary Farrand, and was accepted.

The report of the committee on standard rules for electrical construction and operation, Mr. Charles L. Edgar, chairman, was read by Secretary Farrand. Mr. Edgar explained the incompleteness of the report on the ground that the committee did not get from the underwriters the finished draft of the revision of rules, and so forth, in time to make a complete report.

On motion of Mr. Williams, the report was referred to the executive committee, with power.

MR. NIESZ: Before we adjourn I wish to move a vote of thanks from the association to the retiring president and other officers, for the very efficient, masterly and successful manner in which the affairs of the association have been conducted during the administration just closed.

MR. WILLIAMS: I heartily second the motion, and suggest that it be taken by a rising vote.

(The motion was unanimously carried by a rising vote, after which the meeting adjourned.)

ENTERTAINMENT

Though it is unusual to note in the books of proceedings the entertainment furnished the delegates and their friends at conventions, an exception must be made in the case of the Denver-Colorado Springs meeting, because of its unusual character and extent.

When it was decided to hold the twenty-eighth convention west of the Mississippi, both Denver and Colorado Springs wished to entertain the association, and it was finally arranged to hold the business meeting in Denver for three days, and then adjourn to Colorado Springs for three days of sight-seeing and amusement of various kinds.

While the business of the convention at Denver was not neglected, as the foregoing pages will testify, the "City of Light" did not allow the delegates to become dull through a course of "all work and no play." On Monday evening, June 5, an informal reception, with music and dancing, was held at Brown Palace Hotel. On Tuesday afternoon, the ladies were taken for a drive and luncheon at the Country Club. There being no business session in the evening, all were invited to a theatre party at Elitch's Gardens.

Wednesday's second session was held in the evening, in order to enable the delegates to attend a broncho-busting contest in the afternoon at Denver Athletic Club Park, this being to many of them a novel experience. Some of the worst bronchos and the best riders in the West were brought together for this contest, and it proved of very great interest to all who witnessed it. In the evening, the ladies were again taken to the theatre, and after the business session the men attended a smoker at Coliseum Hall.

While the members attended closely to the work of the convention until a late hour on Thursday, the ladies were taken in the street cars and automobiles to various points of interest in and about Denver. In the evening the George W. Cook Drum Corps gave a serenade in the rotunda of the hotel.

COLORADO SPRINGS

On Friday morning, June 9, the entire party was transported to Colorado Springs, arriving in time to get comfortably settled in the rooms reserved for them at the various hotels. *The Antlers* was the headquarters, but even its large hospitality was unequal to the numbers that thronged to visit this beautiful town—one of the wonder spots of the world; but the work of the hotel committee had been well done, and all were comfortably established and well cared for. The El Paso Club, The Elks Club and the Pike's Peak Club had opened their doors to all who wished to accept the courtesy, and many of the delegates availed themselves of it.

Immediately after luncheon, carriages were furnished and the visitors were driven wherever they wished to go. The power plants were visited. In the evening there was a concert and dancing at Broadmoor Casino.

On Saturday, special trains took the delegates to the Cripple Creek district, and this trip occupied the entire day, luncheon being served on the train. In the evening there was an informal dance at *The Antlers.*

On Sunday, carriages were furnished to take the delegates to points of interest not visited on Friday. There was also a trip to see the sunrise from Pike's Peak, which was taken by a large number of the delegates.

It would be impossible to describe all the points of interest visited, but every one was delighted with the entire entertainment, and went home believing that Colorado and its citizens were in the highest degree charming.

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